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CIVIL ENGINEERING.

On the Construction of Iron Roofs.—By J. J. BIRCKEL.

(Continued from page 240.)

From the London Artizan, Oct., 1862.

EXAMPLE 1, illustrates a roof designed and made by Mr. Rankin of Liverpool, for the Hon. C. Napier's Paper Mill at Dartford. The rafters are trussed on the principle of only one secondary truss; they are made of T iron, 3 in. × 2½ in. × ⅜ in., and bear a stress of about 5½ tons on the square inch; the ties and braces are all made of flat bars, and the pull on the square inch is, for the lower ties, 6 tons, and for the braces 4½ tons, deduction being made for bolt holes. Ventilation is obtained by means of a lantern roof, the standards of which are provided with louvre blades of rolled iron, No. 20 W. G., and are placed at a suitable angle not to allow the rain to enter; skylights of about 5 feet in width extend over the whole length of the roof on both slopes, the glass resting upon T iron sash bars, 2 in. × 1¾ in. × ¼ in., placed about 12 inches apart, which themselves are supported by angle iron purlins of adequate strength. The lower portions, as well as the lantern roof, are covered with slate, which rests upon angle iron laths, 1¼ inch × 1¼ inch × ⅛ inch, placed at distances of 10 inches apart, and though very light are of ample strength, the principals being only 6 feet apart. The method of fixing the slates, is done almost as readily as in the examples already commented upon, without the use of boarding, and is not nearly so heavy; nor is it more expensive, for

upon careful calculation we find that the cost of the iron purlins per square foot of roofing is $2\frac{1}{4}d.$, and the cost of the square foot of $1\frac{1}{4}$ in. boarding, is just the same, if the timber be taken at the moderate price of 1*s.* 9*d.* per cube foot. On the whole, therefore, this is a neatly-designed roof, and is well-proportioned in its chief parts; as there is no particle of wood in the whole structure, its chances of destruction by fire are very small, for it would require a very hot furnace upon the floor of the building—about 20 feet below the roof—to have any appreciable effect upon the latter.

Example 4 illustrates one of the roofs of the Battersea Locomotive Works, now in course of erection, and was designed, we believe, by Mr. Cubitt. The rafters are made of two angle irons, 4 in. $\times 2\frac{1}{2}$ in. $\times \frac{1}{2}$ in., bolted together back to back, with a wood packing between them, for convenience of fastening the boarding, which carries the slates. The thrust upon the rafters, if the load be again assumed at 40 lbs. per square foot, is 22 tons, and, taking into account the bending *moment*, the whole stress upon the square inch is about 10 tons; the tie rod, made of round iron, with suitable bosses forged at the joints, with the vertical ties, has to sustain a maximum pull of $20\frac{3}{4}$ tons, and, the area being 3·14 square inches, sustains a stress of $6\frac{3}{4}$ tons on the square inch. The king post, made of $1\frac{1}{4}$ in. round iron, sustains a stress of 5 tons on the square inch; its junction with the main tie rods, and with the struts of the upper secondary trusses, is made by means of two strong plates, to which the whole of them are bolted, and is one of the neatest arrangements we have yet seen. The struts connecting the king and queen posts are made of T iron, $2\frac{1}{2}$ in. $\times 2$ in. $\times \frac{1}{4}$ in., and sustain a thrust of 4 tons on the square inch; the other struts and vertical ties are proportioned in a similar manner. As the principals are 14 feet apart, there was a necessity for strong purlins, which have been made of two channel irons, 4 in. $\times 1\frac{1}{2}$ in. $\times \frac{1}{4}$ in., bolted together back to back, with a wood packing between them; and the greatest stress upon them will be about 6 tons to the square inch. On the whole, therefore, this roof is very well proportioned, and as it is very neat in the details of its construction, it may with good reason be held forth in all these respects as an example to be imitated. There is one point, however, in its construction which is open to very grave objections, namely, the introduction of the wood packing and planking for convenience of fastening the slates. The weight of iron contained in principal and purlin forming one bay of the roof, is about 32 cwt., and the weight of wood in the same space is about 33 cwt., both materials being, practically speaking, in equal weight. Now, 33 cwt. of wood can develop a quantity of heat equal to that developed by about 16 cwt. of coke, and these, at the ordinary rate of consumption in a cupola, could melt down at least 120 cwt. of pig iron. Should this roof, therefore, by any mischance take fire, if not discovered in time, nothing could save it from utter ruin. It is, of course, not contended that the whole of the iron would be melted down, but the great proportion of wood in contiguity with the iron can leave no doubt upon the minds of our readers that, even should the roof not

come down with a crash, the whole must be so much injured as to be quite unsafe. and unfit for further use. How any one can deceive himself into the belief that he has made a fire-proof building, when he has covered it with a roof like this, is to us a matter of great mystery. But, if the roof is not to be fire-proof, why, we ask, make all its vital parts of iron, or why introduce any iron at all, when it is universally admitted that wooden structures of this kind, notwithstanding the great progress in the manufacture of iron, still remain much cheaper than iron ones? The roof, however, was meant to be fire-proof, and the wood, which in reality forms no part of it, is a matter of secondary consideration only; it is a dead weight which only keeps the slate in its place; its destructive power has not been taken into consideration, and as we shall have occasion presently to show that it can be very well dispensed with, we may safely say that its presence here is a decided mistake.

Example 12 illustrates the roof of a shed at Chatham Dockyard, and was designed by the engineers of the Admiralty; it is covered with corrugated iron, and, in consequence, has a very small rise, the angle being 1 in $4\frac{1}{4}$. With a load of 40 lbs. per square foot, we should have $\frac{1}{4}$ w = 4 tons, and the maximum stress on the rafter would be $22\frac{1}{2}$ tons, to resist which we have a T iron 5 in. × 5 in. × $\frac{1}{2}$ in. equal to 5 square inches in section, and causing a stress of $4\frac{1}{2}$ tons to the sq. inch; this, however, does not take into account the bending stress, although it so happens that at the foot where the thrust is greatest, the purlin sits very nearly at mid distance between two consecutive centres of support. Further up, the purlins sit very nearly upon the centres of support, and as the assumed load of 40 lbs. is considerably greater than it ever will be, there is no doubt that the rafter will be quite strong enough; the maximum pull on the tie rod would be 19 tons, and has an area of $3\frac{1}{3}$ square inches, deduction being made for bolt holes, thus occasioning a stress of about $5\frac{3}{4}$ tons on the square inch. The pull on the king post is about $7\frac{1}{2}$ tons, its area $1\frac{1}{2}$ square inches, and the stress upon the square inch about 3 tons. So far, therefore, this roof is very fairly proportioned; but upon examination of the secondary trusses, we find that the strengths of both struts and vertical ties are out of all reasonable proportion; the pull on the queen rod, for instance, is $2\frac{1}{4}$ tons, its area $2\frac{1}{8}$ square inches, and the stress upon the square inch $1\frac{1}{7}$ tons, while the thrust upon the strut connecting the queen and queen rods is $3\frac{1}{2}$ tons, with an area of 4 square inches, the stress on the square inch being $\frac{7}{8}$ tons. The succeeding struts and ties are similarly proportioned, and the whole of them might have been reduced by the amount of one-half their strength at least. We must also remark that the vertical tie, connecting the upper centre of resistance of the lower truss with the main tie rod, is perfectly useless, as it gives no additional rigidity to trussing. The tie rods, it will be noticed, are made of flat iron of uniform width and thickness, and are a little heavier than they would be if they had been made of uniform area; but as this arrangement avoids all expense of smithing, the final cost is found to be less, in spite of the additional

weight of metal. The struts of the secondary trusses are jointed to the rafters by means of two straps, and are dipped at their lower ends between the main tie rod, which is double for the convenience of making the joints. The corrugated iron covering is carried by means of T iron purlins 5 in. × 4 in. × ½ in., which are stronger than they are really needed, the principals being only 9 feet apart. The shed is lighted from above, by means of two skylights, the glass being carried by T iron sash bars, 2 in. × 1½ in. × $\frac{5}{16}$ in., placed about 12 inches apart, and provision is made for ventilation by means of a louvre roof, raised sufficiently to allow of the free circulation of air. Before concluding our observations on this example, and although we do not intend to enter into the discusssion of the stability of the supports of roofs, we must call attention to the very peculiar case of the pillars supporting the one under consideration. Professor E. Hodgkinson has positively proved by his experiments that pillars with flat bases, of ample area, offer three times the resistance of pillars rounded at the base, the height and transverse section being the same; yet, and notwithstanding this well known fact, have these been almost tapered down to a point:—for what rational purpose we are at a loss to find out.

After careful examination of the examples submitted, we are enabled to draw the inference that in roofs chiefly made of iron, there results no material saving from the introduction of wood for the convenience of merely fastening the covering. And where there are no special causes for the use of wood, as, for instance, a desire or necessity of preserving, as far as possible, an even temperature inside the building, we would strongly deprecate the use of wood, as being an inherent source of danger to the structure of which it forms part. The great calamities which have occurred during the last twelve months are in themselves alone sufficient to justify us in raising a warning voice against the use of a material so suicidal—yet, it is true, so easy and so universal in its adaptation.

Circular Roofs.—From reasons of taste,—and in the case of roofs of very large spans, most probably from reasons of economy,—engineers are sometimes induced to construct roofs in the shape of an arch whose outlines are fixed generally as much by the laws of æsthetics as by those of statics. In such roofs the principal assumes pretty much the character of a linear arch, stiffened by means of a system of trussing, as in the case of a triangular roof; but as the principles of stability of the arch itself have, until within a comparatively recent period, been but imperfectly understood by scientific men, and still remain a matter of great mystery, at the present period, to the greater part of that very respectable body of men called practical engineers, so in proportion to the want of a proper knowledge of this subject, have these gentlemen gone astray from truth in their designs of arched roofs.

One of the earliest structures, nay, we believe the first structure of this description built since the introduction of iron into the architecture of roofs, and which (notwithstanding the inaccuracy of its design as a trussed frame to be pointed out presently) has gained a very great

celebrity—is the roof over the Lime Street Railway Station at Liverpool—and as it has withstood the destructive action of a lapse of time of some thirteen years, it may reasonably be affirmed, also, that it is deserving of that celebrity. The fact, however, of any structure resisting the action of time, and accomplishing the objects for which it was called into existence, is no proof of its being a correct embodiment of scientific truths, but simply proves that so far the structure has proved strong enough; neither should this fact exempt it from a critical analysis, the result of which might prove very useful in future practice.

This roof is described by its designer, Mr. Turner, "as consisting of a series of segmental principals or girders, fixed at intervals of 21 ft. 6 ins. from centre to centre, trussed vertically by means of radiating struts made to act upon the rafters by straining the tie rods and the diagonal braces. Each principal or girder is composed of a wrought iron deck beam 9 ins. in depth, with a plate 10 ins. wide and $\frac{1}{4}$ in. thick, riveted on the top; the upper flanch of the deck beam is $4\frac{1}{2}$ in. wide and $\frac{1}{2}$ in. thick; the lower flange is 3 ins. wide and 1 in. thick. The beam is strengthened at the haunches for a distance of 27 ft. from the springing, by plates 7 ins. broad, and $\frac{7}{8}$ of an inch thick, fastened together by rivets."

Here, therefore, the principal is distinctly described as an arched lattice girder, whose compression and tension flanches are connected by means of a succession of radial struts, and of ties sloping from the centre towards the walls or supports; the depth of the girder diminishes from the centre in the direction of the supports, until the compression and tension flanches meet at each of the extremities. But for this latter feature in its construction, it would be like an ordinary lattice girder, with vertical struts and ties sloping from the bottom of one strut to the top of the following one, in the direction of the supports; the fact of the two flanches meeting, however, alters the case materially, inasmuch as it compels the last sloping rod or tie, as Mr. Turner would have it, to fall upon the compression flanch itself for its support; and when we remember that the strains upon those ties accumulate from the centre of the girder where they are smallest, towards the ends where they reach their maximum, if we construct the diagrams of stresses on this hypothesis, and on the assumed load of 40 lbs. per square foot, we find that the last sloping rod, if it acts as a tie, exerts a component transverse strain upon the rafter or compression flanch, equal to about 35 tons, at a distance of 11 ft. from the wall or column. As the actual direction of that supposed pull is from the wall or columns, and as the principal rests only loosely upon them, we do not see on what principle of dynamics or of statics it is not pulled away from its supports and precipitated into the area below; for hitherto we have been taught, and we have believed, that wherever there is a pressure not balanced, there must be motion in the direction of that pressure; and in the case under consideration, if there is a pull upon the said sloping rod, it cannot be neutralized by the re-action of the wall, for the rafter is the only medium which could connect it with

the wall. It is not supposed to be neutralized by the tension flanch or tie rod, for this could only be effected by a compression strain on the tie rod; and to suppose this would be looked upon by the designer of the roof himself as an absurdity. The only resistance that we can perceive is that offered by the rafter and the tie rod to bending and doubling up in the centre, a resistance which, considering their dimensions, would be of little avail against a component horizontal pull of some 160 tons, with a leverage of 20 ft.; this supposed pull, therefore, could only bring about a dynamical equilibrium, the effect of which must be to bring down the roof.

We think, however, that it will not be difficult to prove that those supposed sloping ties do not act as ties at all, but act as struts; and that the supposed radiating struts act as ties. To this effect we will, for an instant, suppose the principal to be without any weight of its own, and free from all external load; in fact, we will suppose it to be a linear structure capable of resisting any pressure we may choose to apply. At the points we will now apply certain pressures, which to simplify the case, we will suppose to be normal to the curve of the rafter, and of equal intensity on both sides. It is evident that these pressures will produce compression on the portions of the rafter, and on the sloping rods, which compression strains are balanced by a tension strain on the parts of the tie rod; the radial components of the strains by means of the roots are carried to the points where they produce results similar to those produced by the pressures, namely, compression on the portions of the rafter, and on the rods, which are again balanced by a tension strain on the portions of the tie rod, and the same fact reproduces itself upon the successive trusses until the summit of the roof is reached, the several strains accumulating progressively upon the rafter and the tie rod as we approach the extremities of the principal. If now we apply certain pressures at each of the centres of resistance, these respectively will add themselves to the pressures transmitted from each preceding centre of resistance to the radial rods by means of the sloping rods, and the system of trussing thus naturally reduces itself into a series of radial or *quasi* vertical ties connected by means of sloping struts, or king and queen post system of trussing.

To the analysis which has led us to the above conclusion, and to the objection which, no doubt, will be raised by the more superficial inquirer, that if the ties of the Lime Street roof are struts in reality, the roof could not have stood the test of time, we shall give the ready answer, that the fact of the roof having stood this test only proves that, up to the present time, those struts have been able to do their work of resistance, and that the rafter itself, being a strong beam, required little trussing to enable it to do its work. Indeed, if we construct a diagram of stresses on the hypothesis of the principal being a polygonal frame trussed on the system of the king post roof, with an assumed load of 40 lbs. per foot, we find that the stress upon the rafter is a little less than 4 tons per square inch at the foot, and about 8 tons in the centre of the bay; the maximum stress on the sloping struts is 6½

tons, and that on the main tie rods about 9½ tons per square inch, which figures are a clear proof of the correctness of the remarks we have just made. This roof, therefore, if modified in the manner we have suggested, will at all times be an elegant example to imitate; and though we have referred to it as a theoretical blunder (a blunder which will be readily excused when it is remembered that at the time of its construction the theory of structures had not yet been rendered so easily accessible as it is now, with the help of such works as those of Rankine and Mosely), yet it is an example of iron roof construction well worthy of recording, because it represents a great stride in advance of what had previously been effected in roof construction, and must be looked upon as a bold and practically successful conception of the mind of man.

No sooner had the Lime Street roof been fairly tested, than engineers at once entertained the possibility of still greater achievements, and in the year 1853, Messrs. Fox and Henderson constructed the roof over the New Street station at Birmingham, with a maximum span of 212 feet, being 60 feet larger than that of the Lime Street roof, and we believe, up to this time, the largest span known. In its general features, the design of the principal of this roof, resembles much the one previously commented upon. The rafter consists of a plate beam 15 ins. deep, with top and bottom flanches of L iron 6 ins. × 3 ins. × ½ in. thick, and midweb $\frac{1}{16}$ thick; the main tie rod is round, 4 ins. diameter throughout, and with the only difference of the so-called struts being vertical instead of being radial, and of its having crossed diagonals instead of single ones, it may be said to be a copy of the former. Our arguments, therefore, put forward in discussing the nature and merits of the trussing in the Lime Street roof, would apply here again, and would lead us to the same conclusion, namely, that the re-actions take place as in the case of the king post system of trussing, and that the principal should have been constructed according to this system.

In some of its details it differs greatly, and we think unfavorably, with the former; the succeeding lengths of the tie rod, for instance, are connected by being screwed into a wrought iron coupling box, a method very expensive in the first stage of preparing the work, and very troublesome in the subsequent stage of putting it together; the so-called vertical struts are made of four light L irons, distanced by means of cast crosses in such manner as to be farther asunder in mid-length of the strut than at the ends, and assembled by means of bolts passing through those crosses, the whole, it must be perceived, requiring much labor, and on that account being very expensive. The sloping struts having been supposed to act as ties, are comparatively weak, but as there are two diagonals in each bay riveted together at the points where they cross, this defect is greatly lessened, because the length of the actual strut, owing to this circumstance, is greatly reduced.

The design of the roof having been made upon an erroneous assumption, we shall not enter into an analysis of the strengths of the seve-

ral parts of the principals, but shall simply state that, had its designer started from a correct hypothesis, it would, most undoubtedly, have been considerably lighter.

We must notice also that the purlins are made of wood trussed with iron, a fact which we cannot consider an improvement upon the Lime Street roof, either on the score of security or on that of elegance. We have, however, thought proper to introduce it to our readers, because a structure which has the merit of being the largest of its kind in existence must, at all times, be a subject of much interest to all professional inquirers.

Mr. Fairbairn, who was one of the parties consulted about the practicability of Mr. Turner's design, and whose opinion at the time was in favor of it, seems to have given the subject upon which we are engaged his early attention, and, with his habitual sagacity, seems to have arrived at a correct comprehension of it; for in 1857, he caused the boiler yard, now belonging to Messrs. Fairbairn & Co., to be covered in with an arched roof, consisting of two spans of 50 ft., with principal trussed on the system according to which, in the roofs previously analyzed, we have demonstrated the re-actions described to take place. We would not, however, have our readers believe that this is the only way to truss an arched principal correctly, for it might be trussed with theoretical propriety according to our first paper on roofs; but we think that the king post system has a claim to preference, because, on the one hand, it seems to us the more elegant of the two, and because, also, the thrust on the upper portion of the rafter, as we have seen, is considerably less with this system than with the other, a circumstance which here is of much importance, because the almost horizontal position of that portion of the rafter causes the bending stress to be considerably larger for the same vertical load than it is at the foot of the rafter.

If, now, we construct the diagram of stresses with a due regard to this particular feature of the problem that the stress upon any portion of the polygon is represented, both in the primary and in the secondary trusses, by a line drawn parallel to that portion of the polygon, from the point of intersection of the extreme lines closing the diagram of the particular truss of which that portion of the polygon forms part, we find that the rafter which is made of T iron $3\frac{1}{2} \times 3\frac{1}{2} \times \frac{3}{8}$, sustains a stress of about 6 tons on the square inch, and is so small because the purlins have been placed so close to the several centres of resistance as to render the bending stress almost nil; the tie rod is made of $1\frac{1}{4}$ ins. round iron, and sustains a pull of $5\frac{1}{3}$ tons per square inch; the stress on the struts, also, of the upper and lower secondary trusses is about one ton per square inch; the struts are made of T iron, respectively $3\frac{1}{2} \times 3 \times \frac{5}{16}$ and $2\frac{1}{2} \times 2\frac{1}{2} \times \frac{1}{4}$ in. section. The roof is covered with corrugated iron; the principals, which are 11 ft. apart, are carried by strong wrought iron beams, which themselves rest upon the end walls of the building, and between those on two strong cast iron columns 18 ins. diameter, thus causing as little obstruction as possible on the floor below; the shop receives the light from a louvre roof,

glazed in the whole of its width of about 16 ft., and by means of which ample provision is made also for ventilation. On the whole, therefore, this roof is very well proportioned, and in its place it looks exceedingly elegant.

Description of the Drainage of the Borough of Dundee.

By Mr. JOHN FULTON.

From the Lond. Civ. Eng. and Arch. Jour., March, 1863.

It was stated that, previous to 1851, this town was in a most defective condition, in a sanitary point of view. In that year the borough was brought under the powers of the General Police Act for Scotland, but owing to a defect in the drainage clauses of the Act, the sewerage was not commenced until 1856. It however progressed steadily after that date, and was entirely completed in five years, at a cost of £52,000.

In designing this drainage one primary object kept in view was the application of the sewage to some useful purpose, although in the meantime it was allowed to flow directly into the river Tay. Accordingly the whole drainage so far as practicable had been carried to one point —the outlet of a sewer previously constructed by the Harbor Trustees, to intercept the drainage of the town, and prevent it from entering the docks or tidal basins. This sewer had a fall of 1 in 400, was 7 feet high by 3 ft. 9 ins. wide, and its discharging end was 8 feet below the level of mean tide. The sewage discharged by it, in dry weather, measured 2 feet in depth, and during storms 6 feet. The velocity in the former case was 65 feet per minute, and in the latter 116 feet per minute. The drainage had been carried out by a combination of brick sewers and salt-glazed, fire-clay socket pipes, of dimensions suitable for the discharge of the sewage and the flood waters combined. The whole of the brick egg-shaped sewers were provided with invert blocks of glazed fire-clay. The streets drained by tubular sewers were chiefly those at right angles with the river, which were the steepest and therefore the most suitable for tubular drains. The proportion of brick sewers to tubular drains was as 1 to 2, the total length of the former being 10 miles, and of the latter 20 miles; and their cost was nearly as 3 to 1, the average of the former being 33*s.* and of the latter 13*s.* per lineal yard. The leading or intercepting sewers had been made from 12 to 18 inches deeper than the lateral and branch drains, with the view of preventing the ends of the latter from silting. It had been found that, with a fall of 1 in 600, the earthy and more soluble matters were carried off by the ordinary rain-fall and sewage, by a proper system of flushing; but a deposit of sand was left behind in all sewers having no greater fall than 1 in 600. It was not apprehended that much annoyance would arise from this cause, as none of the sewers had a less fall than 1 in 700. Passages with manholes had been carried up to the street level from both the brick and the pipe drains, at the junctions of the leading and lateral sewers, and at distances of 40 yards along each sewer. The junctions for house drains and gullies, con-

sisting of ordinary socket pipes with beveled ends to suit the form of the sewer, were built in as the work proceeded. In the case of tubular mains, socket-junctions having an acute angle were placed at intervals of from 30 to 60 yards apart, or where required for branches, or for gully drains meant for the reception of rain water only. The gases of the sewers were prevented from escaping through the gullies by valves made of stone, and hung with copper links, placed in one side of a small cesspool, the bottom of which was 10 inches below the lower sides of the valves. This form of gully had been found very suitable in Dundee, as the valves freely passed the flood waters, while the cesspools retained all the heavier particles of road detritus. The branch drains had no other trap than the syphon with a cleansing screw, which was placed in immediate contact with the sink, water-closet, or grating used for the reception of soil water, and in such a position as to be easily accessible.

As the water supply was in the hands of a company, it was thought that the expense of flushing the sewers from this source would have been too great. Consequently the plan adopted was to intercept the sewage, and to turn it into any sewer, or series of sewers, that might be desired. This was accomplished by means of cast-iron gates, placed at the junctions of sewers and immediately under manholes, and in this way the greater portion of the sewers had been made self-cleansing.

The flushing gates were 15 inches deep only, and they answered the purpose of overflow weirs, preventing the sewers during floods from being subjected to pressure, by allowing the surplus contents to flow into subsidiary outlets, thus equalizing the flow of water. In sewers having a less fall than 1 in 600, it was found, as already explained, that there was a tendency to the accumulation of sand; and in pipe drains with even a greater fall, where the ordinary house drainage only existed, sand also accumulated. This occasioned the invention of a cleansing apparatus. When a sewer was to be cleansed, a windlass, containing about 45 yards of iron chain, was placed over each of two adjacent entrance ways, 40 yards distant from each other. A series of iron tubes was then put together at the bottom of one manhole, and was pushed by hand to the next, where they were again unscrewed as they were drawn through. The chain being attached to the last rod was by this means carried along the sewer, and affixed to the cleansing tool in connexion with the other chain and windlass. As the matter to be removed usually consisted of hard sand, a tool was first attached to the hooks of the chain, in order to plough or break it up. When this had been sufficiently done, a scraper formed of strong plate iron, and furnished with small wheels or movable axles on its lateral and lower edges, was next drawn through. It usually required to be moved backward and forward several times before the required cleansing was complete. In the case of tubular sewers the plan adopted was somewhat different. The scraper did not require any wheels, and the plough was attached to the end of the entering rod. The cost of cleansing sewers by this mode was on an average, for tubular drains one

penny, and for brick drains twopence per lineal yard. No sewer had hitherto required to be cleansed oftener than once in twelve months.

No ventilation whatever had been applied to the sewers in Dundee, and none was contemplated; for although a length of 30 miles of main sewers, and nearly as many miles of branch drains, all closely trapped, had been in use for several years, not a single complaint had been made regarding foul emanations from them. The sewers were kept free of all silt, except sand, by the flow of the ordinary sewage and rain-fall, regulated by the flushing gates, so that no putrescent substances were retained in the sewers or drains, to fill them with deleterious gases, and to poison the inhabitants. It was believed it was only where sewers were badly constructed, as regarded their form and water-run, that putrid matters were retained in them to bring disgrace on the very name of drainage. It was thought that no sewer under 10 feet in height ought to have an invert of more than 9 inches radius, and that a radius of 6 inches was quite large enough for the invert of any ordinary sewer. When the sewage was confined to such a small compass as this its scouring power was very great; and if care were taken to have the invert blocks laid to a straight line, there would be but little silting, even with a slight fall.

In conclusion, it was stated, as the result of the drainage of the town, so far as could at present be ascertained, that as compared with former years a decided decrease had taken place in the rate of mortality.

Proc. Inst. Civil Eng., Feb. 10, 1863.

International Exhibition.

From the Lond. Mechanics' Magazine, Jan., 1863.

CLASS X, SECTION A—JUROR'S REPORT.

(Continued from p. 233.)

The application of the hydraulic press for the purpose of raising great weights has long been known and adopted in numerous instances, and latterly very extensively by the late Mr. Robert Stephenson, for raising the large tubular girders composing the Britannia and Conway bridges; a similar idea has been conceived by Mr. Edwin Clark, C.E., and applied in a very ingenious manner for raising floating pontoons, which are made to answer the purposes of dry docks for constructing, examining, or repairing vessels. The operation is very simple. A space of water is enclosed, sufficient for the required pontoon, or floating dock, around which are firmly fixed a number of hollow iron columns, in each of which is a hydraulic press and piston, having chains attached to them; these chains are attached at the other end to transverse wrought-iron girders at the bottom of the enclosed water space; the wrought-iron pontoon, which is to carry the vessel, is then floated between the columns, and sunk on to the girders by admitting water into its compartments until it rests upon the bottom of the inclosed water space; the vessel intended to be repaired is then floated over the pontoon, and is placed accurately above it by means of guides; the girders and pontoon, with the vessel upon it, are then raised by

the hydraulic presses, worked by a steam engine and pumps, which act upon the pistons and the chains attached to them, to the cross girders, and as the pontoon rises with the vessel upon it, the water runs freely out of the compartments of the pontoon, and, when the whole is clear, the valves are screwed down from the inside, and the pontoon and vessel are floated away into a basin, and another pontoon is placed in readiness for another similar operation, which generally occupies, for a very large ship, about forty-five minutes. Thus one hydraulic apparatus, with its necessary upright columns, cradle, and basin, or dock space, will answer the purpose of as many dry docks as there are pontoons; and when a vessel has been repaired, the supporting pontoon is again floated over the transverse girders, the valves are opened, and the pontoon sinks gradually, thus leaving the vessel afloat and ready to be taken away. This ingenious adaptation of the hydraulic press is calculated to be very extensively useful in many localities, and to Mr. Edwin Clarke, E.C. (United Kingdom, 2255) a medal has been awarded, for the novelty and general utility of the application.

A large wrought-iron floating dock has been designed, and is being constructed for the Spanish Government by Messrs. G. Rennie and Sons. It is 350 feet long, 105 feet wide, and 37½ feet high, and it will draw, when a vessel of the largest class is in it, about 10 feet. This dock is constructed nearly upon the same principle as the old Dutch Caramel Floating Docks, but is much more complete. It is hollow, is divided into compartments, and is emptied with pumps, worked by a steam-engine placed on the floating dock, so that either by admitting, or by pumping out the water, it can be lowered or raised as may be required, and it can thus be rendered available for any class of vessel. To Messrs. G. Rennie and Sons has been awarded a medal by the Jury of Class XII. for the completeness of the arrangements and the good workmanship of this important construction.

Floating docks upon this as well as upon Clark's system are no doubt very valuable, but it may be a question whether they are likely to supersede the slip system, or that of drawing the vessels out of the water, which can be made equally valuable in certain localities. It is true that the latter system requires that the lower end of the slip should be carried down to the greatest depth, at which a light ship of the largest class can be brought to the lower end of the slip; this cannot be taken at less than sixteen to twenty feet, and to effect this in seas where there is no tide must be attended with considerable expense; and laden vessels cannot, as in Rennie's and Clark's systems, be drawn up, examined, and lowered again within a few hours. Anything by which the old system of heaving down vessels of the ordinary class can be avoided merits attention, as that process is always attended with expense, inconvenience, risk, cost, and delay. The re-introduction of floating docks, on improved principles, has also induced attention to Morton's patent slip, which is now again being brought forward with considerable improvements. All these systems are valuable and usefnl, and can be brought into the public service where the fixed

dock system is considered too expensive, or where the localities are not calculated for such extensive and weighty structures.

Compensating Reservoirs, &c.—With regard to the fourth division—the compensating reservoirs for supplying rivers and streams during summer and dry seasons. This is a most important and valuable system, and it has now become an absolute necessity, as, in consequence of the present superior system of land drainage, a greater proportion of the rain-water which falls upon the land is discharged into the rivers, and is carried off almost immediately after it falls, so that in summer and in dry seasons the lands frequently suffer for want of moisture; the navigation is impeded, and the supply of water for irrigation and for domestic purposes is diminished. Moreover, as sewage matter is now generally discharged direct into the nearest watercourses, the small quantity of water in them in times of drought becomes polluted to such an extent that it is unfit for use, whilst the malaria arising from it is liable to produce disease. The great object, therefore, is to obtain a thorough command of water, so that the land may be properly drained, the sewage be carried off effectually, and that there may be at all times an ample supply of good fresh water for navigation, irrigation, and domestic purposes. A system of compensating reservoirs, established in the most convenient places, along the line of, or adjoining the valleys, through which rivers pass, so that the desired quantity of water may be stored in them during the periods of rainfall, and be discharged again by means of proper sluices, into the rivers and other channels, where required during the summer and dry seasons, is evidently the only proper plan to obviate the serious evils above mentioned, and to combine all the desiderata of complete drainage, sewage, navigation, irrigation, and domestic water supply. This system was largely adopted by the ancients in the valley of the Euphrates, India, and elsewhere, and it contributed largely to the wealth and prosperity of those countries wherein it was practised. It redounds greately to the credit of the French Government and their engineers that this system has been introduced into France with such complete success in many places.

The introduction of this system into Great Britain, has long been advocated by English engineers, who have devoted their attention to the subject, and it cannot be much longer delayed, as works of this kind are now imperatively demanded, both in a sanitary and economical point of view.

Description of the Sewerage and Drainage Works, at Newport Monmouthshire. By Mr. ALFRED WILLIAMS, Assoc. Inst., C.E. F.G.S.

From the Lond. Civ. Eng. and Arch. Journal, March, 1863.

It appeared that, prior to the construction of the works which formed the subject of this communication, several miles of sewers and drains had been built at different times, but mostly in an imperfect manner, and without regard to any general system. There was nine open outlets into the river, varying in level from 5·4 feet to 12·9 feet

below high water of ordinary spring tide; and the tide flowed up the sewers, and sometimes flooded the cellers and basements.

In 1856, the author received instructions from the local board of health to prepare a plan for the drainage of the borough, which he so arranged.—First, that the outlets were reduced from 9 to 4, by intercepting sewers necessary for the drainage of the districts through which they passed; power being retained to use the abandoned outlets, without additional works, should circumstances require it. Secondly, that the sewage of two-thirds of the town might be brought to the lowest outlet down the river, near the extremity of the borough; and by a further expenditure, if events should justify it, the greater portion of the remaining third might be carried to the same outlet, which was a new one selected at a suitable point for the distribution of the sewage matter in a liquid form, or for its conversion into solid manure. Thirdly, that the gradients were generally favorable, considering the level of the great portion of the district, the flattest inclination of any new sewer being 1 in 488 near the lowest outlet, and nearly half the entire length of the new sewers being steeper than 1 in 100. Fourthly, that no cost should be incurred in works, or water for flushing, the plan being so laid out as to take advantage, for cleansing purposes when required, of the land-water, and the waste water from the canal, ponds, feeders, &c., in the town, and water being also obtainable, on an emergency, from the water-works at any point.

The plan comprised about seven miles of new brick sewers, varying in height from 14 inches to 4 ft. 6 in.—all above 14 inches being egg-shaped and narrow at the invert—with outlet works; also of a sufficient number of entrances with ventilating shafts, and of street gullies. The contract for the works was let to Mr. John Phillips, and their cost had amounted to £ 11,862, or about 14 per cent. under the engineer's estimate, which latter was less than the average of nine tenders received for the works.

With reference to the numerous outlets it was mentioned that the case of Newport was exceptional, the size of the river and the extraordinary rise of tide rendering the amount of sewage matter discharged into it comparatively insignificant. Of the four outlets two were old, where a large quantity of land-water was discharged. For the remaining outlets, two points were selected suitable for the utilization of the sewage, if that should be found practicable, and not near any houses—where the sewage would have a short and steep run into the stream at low water, and where only short lengths of pipes would be required. When the outlets were closed, the sewers had for a time to act as reservoirs; but no practical inconvenience was found to arise from this, means of ventilation being provided.

The author did not consider it advisable to use stoneware pipes as main sewers, having regard to the circumstances of the town, the existing works, the relative cost of brickwork and pipes, the quantity of debris washed from the roads into the sewers, the difficulty of preventing improper interference after construction, &c. Under the Newport contract, the cost of radiating brick sewers 14 inches diameter and 4½

inches thick at a depth of 10 feet, with a junction pipe for every house, was 7*s.* 7*d.* per lineal yard. This was about the same as a pipe 12 inches diameter, well laid, with junctions. Sewers 2 ft. 6 ins. by 1 ft. 10 ins. of brickwork, 4½ inches thick, similarly constructed, and large enough for a man to pass through, cost 11*s.* per lineal yard. The author generally recommended brick sewers not less than 2½ feet high for all important lines, excepting where the fall was very great; and he confined the use of pipes to house drainage, for which they were admirably adapted, to short branch sewers on steep inclinations, and to conduits for fresh water.

The bricks were all made by machinery,—the clay having been previously passed through a pug mill,—some by steam and others by hand-power. They had a small longitudinal hollow, which reduced the thickness of the clay, and without materially weakening the brick, caused it to be more dense and more easily burnt. For the 6-inch work, the bricks were 12 inches long by 6 inches deep and 3½ inches thick; and they were found to effect a large saving in many of the sewers, where otherwise two rings of 4½ inch work would have been used. The bricks for the 6 inch and 4½ inch rings were all made to radiate, to suit the invert, side walls, and crown of the several sized sewers; and in order to distinguish readily the different radii, as well as to afford a key for the mortar, grooves varying in shape and number were made in the sides of the bricks. The inner and outer surfaces were curved, so that when well put together a very accurate sewer was formed.

The sewers near two of the outlets having to act as reservoirs for about three hours at spring tides, as previously mentioned, their ventilation was effected by a large number of man-holes and ventilators combined, which were placed in open parts of the centre of the roads and streets at a cost of £4. 10*s.* each complete.

The rate of mortality in Newport in 1850, previous to the adoption of the Public Health Act, was 30·3 per thousand, whilst for the two years ending Michaelmas, 1861, it was rather less than 20 per thousand, or below the average of England and Wales. This very large decrease was, no doubt due, under Providence, to efficient drainage and water supply, to the prevention of over-crowding, and to other sanitary measures.

Proc. Royal Society, Feb., 10, 1863.

For the Journal of the Franklin Institute.

Papers on Hydraulic Engineering. By SAMUEL MCELROY, C. E.

(Continued from page 228.)

No. 3—PUMPING ENGINES.—(Continued.)

General Conclusion.—Having made a distinct analysis of the three divisions of a pumping engine, viz: the pumps, engine, and boilers, it remains to group the several parts together, in some discussion of joint performance.

As to the pumps of large engines, we have noticed the advantages of double-beat valves, the usual defects in suction arrangement and

lift, the relative merits of plungers and buckets, the benefit of direct lines of supply and delivery, and of large openings, the fallacy of uniform motion and short strokes, the doctrine of uniformly variable motion, of loss of action of combined pumps, of force main size and line, and of air chambers.

The single-acting engines have been noticed as to their arrangement in general and detail, their rank as standards of all other classes, their merits in comparison with double-acting engines, the defects of crank motion, the principles of high steam, expansion, momentum, and the defects of combined engines.

The boilers have been noticed as to their varieties of arrangement, furnaces, flues, and tubes, proportions, appurtenances, fuel, general management and comparative economy.

From this subdivision of this subject, in which each part exerts an individual effect on the general result of economy, durability, and perfection of operation, the prominent lesson which is derived, is that of the benefit and necessity of simplicity in form; the highest results being evidently contingent on the most direct and facile lines and method of motion, and the least complicated design.

Careful construction in adaptation to intended work; careful workmanship; and careful management solve the problem of maximum duty, in these three divisions, jointly and severally.

Problem of Duty.—As the coal fed to the furnaces, in one division, and the water delivered to the reservoir in another, form the basis of calculation in engine duty, it is evident that each part must give a maximum result in order to ensure a maximum in the whole combination; and that the engine should be perfectly adjusted in itself to its work, without embarrassment from the boilers on one side, or the pumps on the other. It is also plain that a perfect combination in timid or incompetent hands cannot develop its true measure of results. Educated design is often overruled in the workshop, and seriously injured in anticipated results. If the history of most of our prominent engines was faithfully written, it would utter no unmeaning verdict against those who are "wise above what is written," and foolishly obstinate in that arrogance of opinion, which too often characterizes the half educated. Equally true is it, that the best engines often come short of their real capacities through equally obstinate and prejudiced handling.

Theoretical Duty.—Taking the value of the carbon and hydrogen in one pound of coal, as equal to an evaporation of 14·25 pounds of water, and taking the steam at atmospheric pressure we have the following duty in the boiler.

14·7 pounds per square inch, × 1700 (relative volume) × 144 square inches × 14·25 pounds of water evaporated ÷ 61·13 pounds of water per cubic foot at 212° = 838,819 pounds raised one foot per pound of coal.

At one-third cut-off this duty, multiplied by 2·099 = 1,706,681 foot-pounds, and at one-tenth cut-off, for the ratio of 3·3 = 2,768,102 foot-

pounds, and these amounts vary with various ratios of expansion. They will be also increased by a higher range of boiler pressure, in some degree.

Practical Duty.—As it is a matter of record that some Cornish engines at the mines have repeatedly exceeded *at the pumps* the above *full steam* duty of 838,819 foot-pounds, being reported for monthly averages in certain cases, at 870,000, 885,000, 914,000, 954,000, 961,000, 1,019,000, 1,075,000, and in the experiments of Mr. Wicksteed, at 1,038,037, for 1·12 lbs. coal, in one trial of 117·6 hours, where the evaporation was 8·524 lbs. of water per pound of coal, it follows as an experimental demonstration that there must be a very positive and important gain by expansion, since none of the boilers of these engines yield above 70 per cent. of the theoretical value of the coal, and there are inevitable losses between the boilers and the pumps, by steam radiation, condensation, friction, &c., and engine and pump friction.

In calculating the duty of the Cornish mining engines for the monthly reports, which have been made for many years past, the total amount of coal in bushels, which has been used, and the total number of pump strokes registered form the basis of the report. The coal weight per bushel, has been usually assumed at 94 lbs.; and the total contents of the several pumps, into their different lifts, determine the foot-pounds of water delivered. This process credits the duty account with the item of pump loss of action, but it neglects that of pump friction, the actual lift being taken. It is for the interest of the miners, on their plunger pumps, to keep the former a minimum, and although it cannot be claimed that the calculated duty is a rigidly correct statement, it is fair to assume that these errors in calculation, may in many cases nearly balance each other. The extraordinary lift of many of the mines, ranging in some cases to 1265 feet, and generally exceeding 700 feet, facilitates the pump duty, high lifts being more economical than low ones; the greatest delivery being about 1000 gallons per minute, and the average probably exceeding 300 gallons. The piston load is also heavy, sometimes reaching 18 lbs. per square inch.

Mining engines averaged in this way per year of record, have given returns, as follows (except that of 1855, which is for one month):—

Year.	No. of Engines.	Average Duty.	Average Duty of best Engines.
1838	61	58·	100·2
1839	52	65·4	92·6
1840	54	64·3	97·2
1841	56	65·1	121·3
1842	49	64·0	127 9
1843	36	71·4	114·4
1855	15	68·4	101·3

The figures in the last two columns, being millions of foot-pounds per bushel of coal.

On the supposition of a balance of losses in the pumps, the range

of duty in the last column is 828,000 to 1,142,000 foot-pounds per pound of coal for a bushel of 112 pounds.

In a special trial of an 80-inch engine at Fowey Consols, for 24 $\frac{37}{60}$ hours, by the Cornish rule of calculation, and with coal of 94 lbs. per bushel, the duty was 125·095,713 foot-pounds per bushel, or 1,330,800 foot-pounds per pound of coal.

Taylor's 85-inch engine at United Mines, for September 1842, was reported at 107,000,000 foot-pounds per bushel; the engine using 40 lbs. steam and $\frac{1}{10}$ to $\frac{1}{12}$ cut-off.

The average duty of these engines, as given by Mr. Wicksteed, in 1859, one for 11 years, and the other for 8 years, for New Castle coal, is 75,230,528 foot-pounds for the former, and 83,875,376 for the latter.

In the experiments on the East London Cornish Engine, with weighed coal, in 1840, the pump duty was in one case 97,146,268 foot-pounds per bushel of 112 lbs., the corresponding cylinder duty being 136,127,408 foot-pounds, and for an evaporation of 8·524 lbs. of water per pound of New Castle coal. Boiler pressure 51·7 lbs. cylinder steam 45·7 lbs. steam jacket loss $\frac{1}{2}$ per cent. We have then about 12 per cent. steam loss between the boiler and piston, and 28·6 per cent. between the piston and point of water delivery, being 40·6 in all, while the evaporation is 40 per cent. less than the theoretical standard above assumed.

The average duty of two Cornish engines at this Water-works, also cited in 1859, was for New Castle coal, 95,234,885 foot-pounds, as compared with the above average of the mining engines.

It is also shown in 1840 that while the duty at an expansion of 0·397 of the stroke was 78,535,512 at 0·687 it was 108,198,102 or 37 per cent. better, as applied to an experimental standard of 9·493 lbs. evaporation, in calculating the duty.

Taking the experimental duty of 97,146,268 foot-pounds for 112 lbs. coal, the duty per pound is 867,376 foot-pounds. We have then not only the experimental demonstration of a gain of 37 per cent. between two grades of expansion, but an actual result in pump work, independent of all losses by friction and otherwise, between the boiler and point of water delivery, which exceeds the theoretical duty of one pound of coal in the boiler, at atmospheric pressure and under perfect evaporation, as 867,376 to 838,819. The ratio of gain by expansion chiefly explains this singular result. It is proper however to say, that no loss of action is charged to the pump of 9 ft. stroke by 9·168 square feet area, and 108 ft. actual lift, and no addition is made for force-main friction. In a water-works engine of this kind the former probably much exceeds the latter.

It must also be observed that the total engine friction and the loss between the boiler and cylinder are much above the ordinary experimental losses in Cornish engines; 10 per cent. friction, and 5 per cent. steam waste, being much nearer the usual experience, or a total loss in first class mining engines of 60 to 70 per cent. below theoretical duty, in special trials. The 85-inch engine above mentioned, realized 38·7 per cent. in duty.

Experiments on evaporation uniformly show a loss between actual tank measurement and indicator measurement by volumes. In some cases it ranges to 23·5 and 24·3 per cent., as we have observed it; in other cases it has been reported less. This loss combines the ordinary boiler and cylinder wastes by leakage, priming, condensation, radiation, &c., and is therefore in excess always of simple steam waste.

If then the evaporation loss is taken at 30 per cent., the water and steam loss at 15 per cent. and the engine friction at 20 per cent., which are moderate rates, it is easy to see how the actual gain by expansion is absorbed, and equally plain how incompatible any high range of duty is with full steam stroke.

We also learn from these examples, the prominent rank of the single-acting engine in actual pump duty, in special cases and in a large class, as also for very long periods of time.

The experiments at the East London Water-works, on the Boulton and Watt engine gave a duty of 42,847,598 foot-pounds per bushel of 112 lbs., or 382,568 foot-pounds per pound of coal. The expansion was 0·367 of the stroke, boiler steam 17·7 lbs.

A double-acting engine at Wheal Vor, is reported for June, 1841, at 61,966,317 foot-pounds; another of same size (36-inch) at Tin Croft, in the same report gives 36,971,087 foot-pounds.

The double-cylinder engines of the Thames Dilton class, double-acting, are in several cases reported at high ranges of duty.

An experiment on the four Chelsea engines of this class, August, 1857, in which the duty is calculated from the pump contents, and the equivalent head including pump friction, gives 926,400 foot-pounds per pound of coal; the expansion is eight-fold.

Some of the double-acting engines in the United States have been thus reported.

Pittsburgh, 1841, upper service engines 178,050 foot-pounds; lower service engines 170,648 foot-pounds.

Alleghany City, 1841, 171,667 foot-pounds.

Detroit, 1860. No. 2 engine, 341,111 foot-pounds.

Philadelphia, 1858. Spring Garden engines Nos. 1, 2 and 3, 255,000 foot-pounds.

Experiments with the Cincinnati engines, in 1862, to test the economy of a condenser, had the following results, as to this attachment and as to expansion and pressure.

WITHOUT CONDENSER.		
Boiler Steam.	Cut-off.	Duty.
90	[illegible]	350,633 ft-lbs.
90	[illegible]	405,258 "
110	[illegible]	404,707 "

In the first case, the cylinders were not clothed. In the second this was done, the feed-water heated, and a damper applied to the chim-

ney. In the third case, the feed-water heating arrangement was detached.

WITH CONDENSER.		
Boiler Steam.	Cut-off.	Duty.
90	$\frac{3}{8}$	354,652
90	$\frac{5}{8}$	352,880
90	$\frac{7}{8}$	358,385
80	$\frac{1}{1}$	326,231
40	$\frac{3}{8}$	265,685
115	$\frac{3}{8}$	362,789
90	$\frac{5}{8}$	321,975
110	$\frac{7}{8}$	362,239

The first trial without cylinder clothings, the next three with clothing and feed-heat, and the last four, without the feed-heat. The results showed no advantage in condensing under steam of the ordinary working pressure, and as a running commentary on expansion, give 27 per cent. for a change from $\frac{3}{8}$ to $\frac{5}{8}$ cut-off, and of 115 to 40 pounds pressure.

The duty of the "Bull" engines at the 24th Ward Works, Philadelphia, in 1862, was 385,450 foot-pounds by Cornish rule. At Buffalo, by experiment in 1852, the duty was 370,000 foot-pounds.

The duty of the Cornish engine at Philadelphia for 1858, was 465,400 foot-pounds. At Cleveland for 1862, one engine gave 550,000 and the other 490,000 foot-pounds. On special trial in 1856, the Spring Garden engine (Philadelphia) gave 589,053 foot-pounds.

The pump duty of the Belleville Cornish engine (Jersey City), on special test in 1857, was 680,660 foot-pounds.

The combined cylinder engine at Cambridge, which has about threefold expansion, on special test, without actual measurement of delivery, gave 551,261 foot-pounds.

The Hartford engine on special trial in 1856, gave 591,505 foot-pounds, actual pump duty. The annual duty for 1857, was reported at 592,694 foot-pounds.

The Prospect Hill engine, Brooklyn, which is double-acting, working two pumps from its beam, and connected with a fly-wheel and shaft under special trial in 1862, gave 649,577 foot-pounds for 93 hours trial and 684,042 foot-pounds, for 10 hours of this time.

The duty of the No. 1 engine of Brooklyn, tested in 1860, was 611,114 foot-pounds, and of No. 2, tested in 1862, 606,613 foot-pounds.

It is obvious from these instances, that we have as yet entirely failed to reach either the standard of actual results in the mining engines of the Cornish school, or the results theoretically within reach; and these facts furnish a sufficient comment on the argument presented under each division as to the great need of a more perfect system of design, workmanship, and operation.

If time permitted, it would be a matter of interesting analysis to trace out in the various results above experimentally given, the special

causes which have controlled them, and to show how readily they resolve themselves into an argumentative defence of the prominent laws of action we have presented. We have high steam and expansion vitiated by excessive friction, and light friction vitiated by low steam, improper proportion, and defective expansion; some bad quality or other, constantly counteracting the good ones; pumps badly located, water passages tortuous and contracted, engines overloaded with gearing and frictional resistances or deprived of adequate momentum, and boilers wasting 30, 40, and 50 per cent. of their coal combustion, and a large per centage of their steam. The field of study here is large and of vast consequence; the lines and directions of improvement are plain; the teachings of theory and practice unmistakable.

As a special example in these respects, we may take the Prospect Hill rotative engine, and the Ridgewood engine at Brooklyn.

The former was worked under a boiler pressure of about 45 lbs. steam, with about ¼ th cut-off. Taking one portion of the trial of 11 hours in comparison with another portion of 10 hours, with 149 lbs. coal per hour, a pump load of 28·78 lbs., a cut-off of 0·35, and boiler steam at 22·5, the revolutions were 1233 per hour, while with the same coal, a water load of 28·54 lbs., boiler steam 44·3 lbs., and cut-off 0·145, the revolutions were 1379 or 11·2 per cent. better. Comparing two observations together of two distinct hours, where the expansion in one case was 0·35, and in the other 0·05, the relative duty of the latter was 58 per cent. better than the former. And yet the engine, as a whole, like all others of its class, was defrauded of any high range of duty, by its losses in friction, steam waste, and evaporation.

On the other hand, the Ridgewood engine, which has less than 8 per cent. friction between the piston and pump, and which has never been worked Cornish fashion, and has not now by a number of tons, its proper counterweight, which works with 18 pounds boiler pressure and 8 lbs. cylinder steam, cutting-off at 0·4, obtains its duty of 611,000 foot-pounds, under conditions which are manifestly unfavorable to high results and solely through its perfection of motion. Properly adjusted and operated, there would be no trouble in carrying it up to 1,000,000 foot-pounds duty.

In the latter case, it was proved by a series of gradual improvements in 1859, resulting from increased pressure in the boiler and increased weight on the beam, that the progress towards maximum performance was strictly defined; and the results with the second engine fully confirmed the theory, though vitiated by neglect of its proper development. As an illustration of the effect of increased load, the dotted line of the pump card, noticed at page 299, vol. xliv, is given. This shows greater smoothness of action and less loss in power, in confirmation of the general theory advanced. The results which will be obtained when these engines are worked under proper expansion, cannot fail to confirm the Cornish experience in this respect; an experience which furnishes the engineering world with a forcible argument on the benefits of carefulness in design and simplicity in operation.

(To be Continued.)

The Economic Construction of Girders.

From the Lond. Civ. Eng. and Arch. Jour.

The following corrections in the original articles have been sent to us by the author, Robert H. Bow, Esq., Civil Engineer, Edinburgh.

EDITOR.

Corrigenda.

VOL. XLIII.

Page 302, second line above Table II, take out the word "so."

VOL. XLIV.

Page 25, Formula (5), For $x = \left(\frac{a_1 + c}{a_1\ c}\right.$ &c., read $x = c\left(\frac{a_1 + a_1}{a_1\ c}\right.$ &c.

Page 26, first line above table, for "*at*," read "as;" also the same at next formula.

Page 82 line 29 from bottom, for "As the above title," read "As this title."

Page 85, line 6, for "each part made," read "each part of the web made."

Page 153, line 12 from bottom, for "=0·10297," read "=0·11297."

Page 154, lines 15 to 19, take out all.

Page 313, line 4, for the word "fully," read "nearly."

Page 316, line 8 from bottom for "*e*1," read "*e* : 1."

Page 318, line 2 from top, for "*i*″" read "*one inch.*"

Page 318, line 10 from top, for "$\frac{1}{s}$," read "$\frac{1}{8}$."

Page 380, line 6, take out the word "the."

Page 380, line 11 from bottom, for "*c*" at head of column in table, read "c."

Page 382, line 28, for "formulæ," read "formula."

VOL. XLV.

The foot note on page 16 and the first on page 20 should be transposed.

ROBERT H. BOW.

MECHANICS, PHYSICS, AND CHEMISTRY.

Results of an Experimental Inquiry into the Comparative Tensile Strength and other Properties of various kinds of Wrought Iron and Steel. By MR. DAVID KIRKALDY.

From the Mechanics' Magazine, December, 1862.

Mr. Kirkaldy exhibited several cases of the fractured specimens upon which his experiments were made; and, by way of introduction to the discussion, there were read from his Treatise the following conclusions arrived at by Mr. Kirkaldy in the course of his inquiry:—

1. The breaking strain does *not* indicate the quality as hitherto assumed.

2. A *high* breaking strain may be due to the iron being of superior

quality, dense, fine, and moderately soft, or simply to its being very hard and unyielding.

3. A *low* breaking strain may be due to looseness and coarseness in the texture, or to extreme softness, although accompanied by very close and fine quality.

4. The contraction of area at fracture, previously overlooked, forms an essential element in estimating the quality of specimens.

5. The respective merits of various specimens can be correctly ascertained by comparing the breaking strain *jointly* with the contraction of area.

6. Inferior qualities show a much greater *variation* in the breaking strain than the superior.

7. Greater differences exist between small and large bars in coarse than in fine varieties.

8. The prevailing opinion of a rough bar being stronger than a turned one is erroneous.

9. Rolled bars are slightly hardened by being forged down.

10. The breaking strain and contraction of area of iron plates are greater in the direction in which they are rolled than in a transverse direction.

11. A very slight difference exists between specimens from the centre and specimens from the outside of crank-shafts.

12. The breaking strain and contraction of area are greater in those specimens cut lengthways out of crank-shafts than in those cut crossways.

13. The breaking strain of steel, when taken alone, gives no clue to the real qualities of various kinds of that metal.

14. The contraction of area at fracture of specimens of steel must be ascertained as well as those of iron.

15. The breaking strain, *jointly* with the contraction of area, affords the means of comparing the peculiarities in various lots of specimens.

16. Some descriptions of steel are found to be very hard, and consequently, suitable for some purposes; whilst others are extremely soft, and equally suitable for other uses.

17. The breaking strain and contraction of area of *puddled* steel plates as in iron plates, are greater in the direction in which they are rolled; whereas in *cast* steel they are less.

18. Iron, when fractured suddenly, presents invariably a crystalline appearance; when fractured slowly, its appearance is invariably fibrous.

19. The appearance may be changed from fibrous to crystalline by merely altering the shape of the specimen so as to render it more liable to snap.

20. The appearance may be changed by varying the treatment so as to render the iron harder and more liable to snap.

21. The appearance may be changed by applying the strain so suddenly as to render the specimen more liable to snap, from having less time to stretch.

22. Iron is less liable to snap the more it is worked and rolled.

23. The "skin" or outer part of the iron is somewhat harder than the inner part, as shown by appearance of fracture in rough and turned bars.

24. The mixed character of the scrap iron used in large forgings is proved by the singularly varied appearance of the fractures of specimens cut out of crank-shafts.

25. The texture of various kinds of wrought iron is beautifully developed by immersion in dilute hydrochloric acid, which, acting on the surrounding impurities, exposes the metallic portion alone for examination.

26. In the fibrous fractures the threads are drawn out, and are viewed externally, whilst in the crystalline fractures the threads are snapped across in clusters, and are viewed internally or sectionally. In the latter cases the fracture of the specimen is always at right angles to the length; in the former it is more or less irregular.

27. Steel invariably presents, when fractured slowly, a silky fibrous appearance; when fractured suddenly the appearance is invariably granular, in which case also the fracture is always at right angles to the length; when the fracture is fibrous, the angle diverges, always more or less from 90 degrees.

28. The granular appearance presented by steel suddenly fractured is nearly free of lustre, and unlike the brilliant crystalline appearance of iron suddenly fractured; the two combined in the same specimen are shown in iron bolts partly converted into steel.

29. Steel which previously broke with a silky fibrous appearance is changed into granular by being hardened.

30. The little additional time required in testing those specimens, whose rate of elongation was noted, had no injurious effect in lessening the amount of breaking strain, as imagined by some.

31. The rate of elongation varies, not only extremely in different qualities, but also to a considerable extent in specimens of the same brand.

32. The specimens were generally found to stretch equally throughout their length until close upon rupture, when they, more or less, suddenly drew out, usually at one part only, sometimes at two, and, in a few exceptional cases, at three different places.

33. The ratio of ultimate elongation may be greater in short than in long bars in some description of iron, whilst in others the ratio is not effected by difference in the length.

34. The lateral dimensions of specimens form an important element in comparing either the rate of, or the ultimate, elongations—a circumstance which has been hitherto overlooked.

35. Steel is reduced in strength by being hardened in water, while the strength is vastly increased by its being hardened in oil.

36. The more highly steel is heated (without, of course, running the risk of being burned) the greater is the increase of strength, on its being plunged into oil.

37. In a highly converted or hard steel, the increase in strength and in hardness is greater than in a less converted or soft steel.

38. Heated steel, by being plunged into oil, instead of water, is not only considerably *hardened*, but *toughened* by the treatment.

39. Steel plates hardened in oil, and joined together with rivets, are fully equal in strength to an unjointed soft plate, or the loss of strength by riveting is more than counterbalanced by the increase in strength by hardening in oil.

40. Steel rivets, fully larger in diameter than those used in riveting iron plates of the same thickness, being found to be greatly too small for riveting steel plates, the probability is suggested that the proper proportion for iron rivets is not, as generally assumed, a diameter equal to the thickness of the two plates to be joined.

41. The shearing strain of steel rivets is found to be about a fourth less than the tensile strain.

42. Iron bolts, case-hardened, bore a less breaking strain than when wholly iron, owing to the superior tenacity of the small proportion of steel being more than counterbalanced by the greater ductility of the remaining portion of iron.

43. Iron highly heated, and suddenly cooled in water, is hardened, and the breaking strain, when gradually applied, increased, but, at the same time, it is rendered more liable to snap.

44. Iron, like steel, is softened, and the breaking strain reduced, by being heated and allowed to cool slowly.

45. Iron, subjected to the cold-rolling process, has its breaking strain greatly increased by being made extremely hard, and not by being "consolidated," as previously supposed.

46. Specimens cut out of a crank-shaft are improved by additional hammering.

47. The galvanizing or tinning, of iron plates, produces no sensible effects on plates of the thickness experimented on. The results, however, may be different should the plates be extremely thin.

48. The breaking strain is materially affected by the shape of the specimen. Thus the amount borne was much less when the diameter was uniform for some inches of the length than when confined to a small portion—a peculiarity previously unascertained, and not even suspected.

49. It is necessary to know correctly the exact conditions under which any tests are made, before we can equitably compare results obtained from different quarters.

50. The startling discrepancy between experiments made at the Royal Arsenal, and by the writer, is due to the difference in the shape of the respective specimens, and not in the difference in the two testing machines.

51. In screwed bolts, the breaking strain is found to be greater when old dies are used in their formation than when the dies are new, owing to the iron becoming harder by the greater pressure required in forming the screw thread when the dies are old and blunt, than when new and sharp.

52. The strength of screw-bolts is found to be in proportion to

their relative areas, there being only a slight difference in favor of the smaller, compared with the larger sizes, instead of the very material difference previously imagined.

53. Screwed bolts are not necessarily injured, although strained nearly to their breaking point.

54. A great variation consists in the strength of iron bars which have been cut and welded; whilst some bear almost as much as the uncut bar, the strength of others is reduced fully a third.

55. The welding of steel bars, owing to their being so easily burned by slightly overheating, is a difficult and uncertain operation.

56. Iron is injured by being brought to a white or welding heat, if not at the same time hammered or rolled.

57. The breaking strain is considerably less when the strain is applied suddenly, instead of gradually, though some have imagined the reverse is the case.

58. The contraction of area is also less when the strain is suddenly applied.

59. The breaking strain is reduced when the iron is frozen; with the strain gradually applied, the difference between a frozen and unfrozen bolt is lessened, as the iron is warmed by the drawing out of the specimen.

60. The amount of heat developed is considerable when the specimen is suddenly stretched, as shown in the formation of vapor from the melting of the layer of ice in one of the specimens, and also by the surface of others assuming tints of various shades of blue and orange, not only in steel, but also, although in a less marked degree, in iron.

61. The specific gravity is found generally to indicate pretty correctly the quality of specimens.

62. The density of iron is *decreased* by the process of wire-drawing, and by the similar process of cold-rolling, instead of *increased*, as previously imagined.

63. The density in some descriptions of iron is also decreased by additional hot-rolling in the ordinary way; in others the density is very slightly increased.

64. The density of iron is decreased by being drawn out under a tensile strain, instead of increased, as believed by some.

65. The most highly converted steel does not, as some may suppose, possess the greatest density.

66. In cast steel the density is much greater than in puddled steel, which is even less than in some of the superior descriptions of wrought iron.

The breaking strain per square inch of wrought iron is generally stated to be about 25 tons for bars and 20 tons for plates. This corresponds very nearly with the results of the writer's experiments, of which the following table presents a condensed summary:—

	lbs. Highest.	lbs. Lowest.	lbs. Mean.	Tons.
188 bars rolled,	68,818	44,584	57,555	= 25¾
72 Angle iron, &c.,	63,715	37,909	54,729	= 24½
167 Plates lengthways,	62,544	37,474	50,737	= 21¾
160 Plates crossways,	60,756	32,450	46,171	

Although the *breaking* strain is generally assumed to be about 25 tons for bars and 20 tons for plates, very great difference of opinion exists as to the amount of *working* strain, or the load which can with safety be applied in actual practice. The latter is variously stated at from a third to a tenth. It will be observed that whilst much discussion has arisen as to the amount of working strain, or the ratio the load should bear to the breaking strain, the important circumstance of the *quality* of the iron, as influencing the working strain, or the ratio the load should bear to the breaking strain, the important circumstance of the *quality* of the iron, as influencing the working strain, has been overlooked. The Board of Trade limits the strain to five tons, or 11,200 lbs. per square inch.

It must be abundantly evident, from the facts which have been produced, that the breaking strain, when taken alone, gives a false impression of, instead of indicating, the real quality of the iron, as the experiments which have been instituted reveal the somewhat startling fact, that frequently the inferior kinds of iron actually yield a higher result than the superior. The reason of this difference was shown to be due to the fact, that whilst the one quality retained its original area, only very slightly decreased by the strain, the other was reduced to less than one-half. Now, surely this variation, hitherto unaccountably completely overlooked, is of importance, as indicating the relative hardness or softness of the material, and thus, it is submitted, forms an essential element in considering the safe load that can be practically applied in various structures. It must be borne in mind that although the softness of the material has the effect of lessening the amount of the *breaking* strain, it has the very opposite effect as regards the *working* strain. This holds good for two reasons: first, the softer the iron the less liable it is to snap: and, second, fine or soft iron, being more uniform in quality, can be more depended upon in practice. Hence the load which this description of iron can suspend with safety, may approach much more nearly the limit of its breaking strain than can be attempted with the harder or coarser sorts, where a great margin must necessarily be left.

Special attention is now solicited to the practical use that may be made of the new mode of comparison introduced by the writer, viz: *the breaking strain per square inch of the* FRACTURED *area of the specimen, instead of the breaking strain per square inch of the* ORIGINAL *area.*

As a necessary corollary to what he has just endeavored to establish, the writer now submits, in addition, that the *working* strain should be in proportion to the breaking strain per square inch of fractured area, and not to the breaking strain per square inch of the original area, as heretofore. He does not presume to say what that ratio

should be, but he fully maintains that some kinds of iron experimented on by him will sustain with safety more than double the load that others can suspend, especially in circumstances where the load is unsteady, and the structure exposed to concussions, as in a ship, or to vibratory action as in a railway bridge.

The writer has not attempted to explain the cause of the mysterious change produced on steel by heating it and plunging it into water, or the no less singular result effected by plunging it, when heated, into oil. Neither has he tried to account for the mysterious change produced by subjecting iron to the processes of cold-rolling or wire-drawing. The explanation offered by some, of this difficult question, that the iron or steel are *condensed* by the processes to which they are subjected, is completely contradicted by fact, the metal being actually *expanded*. The aim of the writer being strictly to ascertain facts, and state the conclusions which he considers to be fairly deducible from them, he has not felt himself warranted in attempting to speculate on a subject respecting which so little is yet known.

In conclusion, the writer ventures only to express a hope that the experiments, on which he has been so long and unremittingly engaged, may not prove wholly unserviceable to practical science and the world at large. The importance of possessing a thorough knowledge of the capabilities and strength of substances on which the lives and property of so many human beings depend, no one will attempt to deny. The only excuse, if, indeed, excuse it can be called, for employing an inferior description of material in the rearing of structures on the stability of which such momentous issues are involved, is ignorance or misapprehension of its proper quality. The writer has endeavored, by a plain statement of facts, to furnish some information on a subject which seems, until now, to have been denied the attention which its paramount importance demands. Were this question fairly taken up and considered, some security might be afforded against the repetition in future, of disasters occasioned by its being so often practically ignored. The necessity of using nothing but the very best description of metal, where human life or valuable property is at stake, may, he trusts, come soon to be more generally recognised than it is at present. And an increased demand for the finer varieties may conduce to a generous emulation amongst the manufacturers to improve still further the quality of their productions. Should his labors tend in any way, even the smallest degree, to diminish the annual sacrifice of life and property occasioned by faulty material and workmanship, he will feel the satisfaction that, they have at least, not been entirely in vain.

Mr. Kirkaldy exhibited 490 selected specimens, which were contained in five cases, namely:—

In Case I.

9 iron bars, showing elongation and lateral contraction.
1 iron plate, do.
1 steel plate, do.

In Case II.

42 steel bars, showing fractures and contraction of area.
105 iron bars, do.

IN CASE III.

36 steel plates, showing fractures and contraction of bars.
60 iron plates, do.
24 angle iron, &c.. do.

IN CASE IV.

36 iron bars, showing fractures and effects of difference of shape.
40 iron bars, showing fractures and effects of difference of treatment.
12 steel bars, do.
10 iron plates, do.
15 iron bars, showing fractures and effects of strains suddenly and gradually applied.

IN CASE V.

46 iron bars, showing fractures of screwed bolts.
12 iron bars, showing fractures of welded joints.
2 steel bars, do.
26 iron bars, showing texture as developed by acid.
8 iron plates, do.
1 iron plate, with surface cold-rolled.
4 iron bars, with surface cold-rolled.

For the Journal of the Franklin Institute.

Fluid Resistance. By JOHN A. GRIER.

In this brief article I will not attempt to investigate the abstruse question of fluid resistance as a whole, but simply desire to attract attention to a single phase of this most interesting subject.

If I am able to make my views distinctly understood, concerning the front resistance which a vertical plane meets with and has to overcome, in passing through a fluid in a direction perpendicular to this plane, I will have accomplished my design.

The amount of resistance for any one velocity is not desired,—but simply the relative resistance at different velocities.

The theoretical question is this: Suppose we have a vertical plane totally submerged, and moving through a fluid in a direction perpendicular to this plane but at variable velocities, how will the resistance and the power necessary to overcome this resistance vary, in order to move the plane with these variable velocities?

In order to be more distinctly understood, I will explain that I understand *the resistance overcome* to be a true criterion of the power expended, in whatever way this power may be developed.

The well known law always given and never disputed is: That the resistance varies as the square of the velocity.

But this law is differently understood, some understanding it to mean the resistance for a *certain space* moved through, and others for a *certain time*.

So to avoid this ambiguity of expression that is so easily mistaken, I would lay down my view of this law more explicitly, thus: The front resistance that a plane moving through a fluid in a direction perpendicular to this plane will meet with, during a *certain time*, will vary as the square of the velocity. And that the front resistance which this same plane will meet with, while passing through a *certain space*, will vary simply as the velocity.

This view of the question is taken by Olmstead and Arnott, while a different view is more generally accepted by men eminent for their practical and theoretical abilities in engineering, I will simply cite two instances, Bourne, the great English author on steam engineering, and J. Scott Russel, the builder of the *Great Eastern.*

Olmstead and Arnott say, that the power necessary to be expended to overcome the front resistance of a steamer for a *certain time* varies as the square of the velocity, but Olmstead and Arnott were not practical men perhaps,—so Bourne, Russel, and hundreds of others, who are the *practical builders* of our steamers, say that the power necessary to overcome this theoretical front resistance varies as the cube of the velocity.

And engineers of all kinds, who try to add just one knot more to the speed of their vessels, when they have already attained a high speed, know that the fuel expended in obtaining this extra knot is an increase of a very large per centage on the normal quantity of coal consumed.

But that to increase the speed of a vessel from half her average speed to her average speed, would increase the consumption of coal as much as eight-fold as Bourne and the believers of the cube theory teach, is something with which my own experience for several years does not agree.

So first we will endeavor to settle the question practically in this manner. If there is to be an increase of speed of a steamer beyond her ordinary fast speed, the expenditure of power or the expenditure of fuel is increased in a greatly increasing ratio, sometimes even exceeding the cube of the velocity.

This can be accounted for by the increased inefficiency of the propelling instrument (whether it be a screw or a side-wheel), moved at very high velocities, and to the forced and incomplete combustion of the fuel. There are other causes, but these two are the principal ones.

When the vessel's speed is increased from half her average speed to her average speed, these two causes affect the results but very little; hence we may not wonder if by increasing the quantity of fuel per hour four or five-fold, it does increase the speed from half the average speed to the average speed. It is an experiment I have frequently tried with these results.

But let the practical question be settled as it may, for the present the theoretical front resistance is what we wish to consider.

The reasoning on this subject is this: If, during a *certain time*, we double the velocity of the plane we double the number of particles struck during this *certain time*, and also strike each one with a double velocity.

As the resistance varies as the number of particles struck, multiplied by the velocity with which they are struck, we have this fourfold resistance for this *certain time* accounted for. Or we have a reason for this law; that the resistance to our plane for a *certain time* will vary as the square of the velocity.

If the resistance for a *certain time* varies as the square of the velo-

city, the power which will be necessary to be expended during this *time* to overcome this resistance, will also vary as the square of the velocity.

And from this it is also deduced, that the resistance for our plane moving through a *certain space* as well as the power that is necessary to be expended in overcoming this resistance varies as the velocity simply.

Hence, practically speaking, *if the front resistance of a steamer was alone to be considered, to double the speed while going from one port to another, would require an engine of the ability to develop a quadrupled quantity of power during a certain time, but consuming only a double quantity of fuel.*

The *quadrupled* increase in the engine's capabilities to develop power would be required, in order to develop this *double* quantity of power required in one-half the time that the engines would have to develop it, if the steamer was moving at the slower speed.

Hence, to double the speed of a steamer, if the front resistance was the only resistance to be overcome, and if there was no direct loss of power on account of the increased velocity of the engines or forced combustion of the fuel, then the quantity of fuel consumed to drive the steamer at a double speed for a *certain space* would have to be increased two-fold only, and this doubled quantity of fuel would develop from our *four-fold increased engine only a double quantity of power.*

If this four-fold increased engine in our fast steamer was to develop power for the same *length of time*, as the single engine in the slow steamer, then the quantity of fuel consumed, or power developed, would also be increased four-fold.

These exact results in practical steamship propulsion, of course, could not be expected, but because they are not realized we are not obliged to arrive at erroneous conclusions on the whole subject.

Although the angular entrance of an ordinary steamer decreases the front resistance to a very great extent, when compared with the resistance the bow would meet with if rectangular, yet the principle holds good, that the particles of water must be driven from a bow of a certain form, with velocities varying as the speed of the steamer.

Now, I will endeavor to explain the deductions from experiments on which the advocates for the cube theory base their theory.

I will endeavor to prove most conclusively why it is that this erroneous theory receives so general acceptance.

By direct experiment it has been shown, that if a weight be attached to a cord running over a pulley, and then made fast to a body floating in a fluid, so that the descending weight will pull the floating body through the fluid with a certain velocity, then, to double the velocity of this floating body, the weight must be increased *four times.*

And as at this double velocity the large weight would have to move through twice the *space* to overcome the resistance of the floating body for the *same length of time*, it is estimated that the power developed by the force of gravity acting on this descending weight, in order to double the velocity of the floating body *for a certain time* varies as 8 : 1.

Thus, weight 1 multiplied by space 1 is said to represent the mechanical effect of the small weight; while weight 4 multiplied by space 2 is said to represent the mechanical effect of the large weight.

A most accurate and careful set of experiments were made by the French Academicians D'Alembert, Bossuet, and Condorcet, in 1787, and the results of these experiments seem to have been so conclusive as to have been received without doubt.

The height through which the weight fell, multiplied by the weight, varied nearly as the cube of the velocities with which they drew the float through the fluid.

However, these experiments are not the only foundation for the cube theory, as Bourne, in discussing this subject, asserts that *Newton is wrong* in thinking that if a body is put in motion by an expenditure of a certain definite quota of power, then to put this same body in motion again with *double* its former velocity will require but a *double* expenditure of power.

Bourne's theory is, that if a body is put in motion by a certain expenditure of power, then it would require a *quadrupled* expenditure of power to give a similar body a *double* velocity. This theory he thinks he proves conclusively by the laws of gravity, and if his views on that subject are not erroneous, he undoubtedly proves this theory on momentum as correct, as well as his cube theory or fluid resistance.

In an article on momentum, published in the January number of this *Journal*, I have asserted:—"That the generally received criterion of 'work done,' or 'mechanical effect,' 'power expended,' or 'resistance overcome,' being the space through which a body is moved, was erroneous."

The height through which a body is raised multiplied into its weight is a gauge for "work done" or "mechanical effect," more universally used than a two foot-rule is for measuring dimensions.

If an incorrect gauge is used, no wonder that there are some striking discrepancies in conclusions.

If we can determine the *actual resistance overcome*, when a body is moved through a space during a certain time, that, and that only, will be a true, unvarying criterion for mechanical effect.

It is well determined, both from theory and experiment, that if an initial velocity be given to a body in an upward direction, sufficiently great to raise it 16 feet during one second, it will overcome the uniform resistance of gravity for one second. Then to give a similar body double this initial velocity, it will raise the body not 32 feet, but 64 feet, and be two seconds in doing this work, or it will overcome the uniform resistance of gravity for two seconds.

Hence, although the spaces through which these bodies are raised vary as 1 : 4, the resistance of the force of gravity overcome, or the power expended in overcoming this resistance of the force of gravity varies as 1 : 2.

No example can be more simple or more striking. If *it* fails to convince, reading the remainder of this article will, I fear, be time lost to the reader.

It is on this *false* criterion of mechanical effect—"*height multiplied into space*," that Bourne defiantly plants his flag as an advocate for the truth of the cube theory.

This false criterion receives universal approbation from all writers on mechanics. It is taught in all our books, and from the desk of every professor of natural philosophy in our schools.

If this is not sufficient evidence to rob it of even a shadow of error, then we may have the temerity to boldly question its correctness. My "*ipse dixit*" is not worth the paper on which it is written,—and perhaps it will be said my reasoning is on a par with it in value, but if my reasoning on this subject will bear the test of examination, then our books on mechanical science will stand a slight overhauling to advantage,—and our philosophical professors may re-write some of their lectures. For several years I have particularly noticed the discrepancy on this subject, and have anxiously and patiently waited for some master-mind to unravel the mystery. Page after page has been written, but no one appears to have drawn the curtain to one side.

If success should crown my effort, I shall be sufficiently repaid for my seemingly independent course of thinking, and thus trifling with the opinions of high authorities.

The criterion of *resistance overcome* is the pivot on which the whole subject beautifully turns.

If in any of the experiments recorded where the velocity varies as 1:2 we multiply the height through which the weights descended for a *certain time*, by the weights, while they were overcoming the resistance of the floating body,—then, the mechanical effect of the force of gravity developing power—*does vary as the cube of the velocity.*

But, if we multiply the times during which the uniform force of gravity was developing power, (which times being equal,) into the weights, which varied as 1:4, then the mechanical effect which the uniform force of gravity developed would vary as 1:4, *or as the square of the velocity simply.*

This fact is elegantly illustrated in the experiments made by the French Academicians as recorded in their Memoirs.

They may not have observed it particularly,—as this series of experiments were introduced to prove the cube theory beyond a doubt, and are referred to for such proof to this day.

If it is true that the force of gravity does develop four times as much power when it draws a body through a space of 64 feet in two seconds, that it does in drawing it through 16 feet in the first of these two seconds, then the cube theory is correct.

It is evident that experiments and deductions made with a false criterion of mechanical effect are vitiated in their conclusions.

With this understanding, several years ago, I made an experiment on fluid resistance with the following results:

The experiment was a rude one however, the details, of which I have lost, and with my present facilities, I cannot repeat it.

Two light metallic planes were so weighted as to keep the top side uppermost, and of a specific gravity but little greater than the water,

and so filled in on the under side as to diminish the resistance of the water dragging after them as much as possible. So that when these planes were drawn up by cords from a depth of water of about twenty feet, the great portion of the resistance was front resistance.

By a crank and axle having two diameters varying as 1:2, a coincident motion was obtained for each, but with velocities varying as 1:2.

A common spring balance was secured on the cord between the surface of the water and the axle.

This spring balance self-registered the maximum strain on each cord.

This strain on the cords as registered by their respective balances varied nearly as 1:2,—and not as 1:4.

To me it seemed to prove conclusively that the resistance for these planes, while moving during a *certain time*, varied as the square of the velocity,—and for a *certain space* as the velocity simply.

Hence the power required to overcome the resistance for a *certain time* would vary as the square of the velocity, and for a *certain space* as the velocity simply.

The practical bearing of this subject on the *grand* question of steamship resistance and propulsion, is very important, to say nothing of its influence on other great engineering questions.

The settling of it beyond dispute is a subject well worthy of the attention of those whose authority on such subjects could be received with confidence.

My authority, I know, is worthless,—my views on mechanics are bounded by narrow limits, and my attainments are very moderate; therefore I should deeply regret leading any one astray,—if my firm convictions on this subject are erroneous.

Association for the Prevention of Steam Boiler Explosions, Manchester.

From the Journal of the Society of Arts, No. 517.

The engineer's monthy report, made Tuesday, September 30th, 1862, states as follows:—

"I am happy to be able again to report that no explosion has happened during the past month to any boiler under the inspection of this Association, neither has the occurrence of any in other quarters come to my knowledge.

"During the past month there have been examined 263 engines and 451 boilers. Of the latter, 15 have been examined specially, 6 internally, 72 thoroughly, and 358 externally; in addition to which, 4 of these boilers have been tested by hydraulic pressure. The following defects have been found in the boilers examined:—Fracture 8 (1 dangerous); corrosion, 49 (8 dangerous); safety-valves out of order, 3; water gauges ditto, 14; pressure gauges ditto, 4; feed apparatus ditto, 3; blow-off cocks ditto, 16 (1 dangerous); fusible plugs ditto, 5; deficiency of water, 1; blistered plates, 3 (1 dangerous); total, 106 (11 dangerous). Boilers without glass water gauges, 5; without blow-off cocks, 17; without back pressure valves, 25.

"Two boilers have recently been met with, neither of which was fitted with its own separate safety-valve, but both were dependent on a single one placed upon the steam-pipe, the communication between which and each boiler was conditional on its junction-valve being open, so that had the attendant at any time inadvertently left this valve screwed down—on getting up steam, for instance, on a change of boilers—the whole steam pressure must have been bottled up without chance of escape.

"Feed Back-Pressure Valves.—Some of our members do not appear to be fully aware of the importance of fixing a feed-back pressure valve to each of their boilers, and therefore the following instance, lately met with, of the inconvenience arising from the want of them, may be given.

"Four boilers, set side by side, and connected together, were working under their ordinary circumstances, when one of them vomited its water through the feed-pipe into the adjoining one, draining itself and over-charging the other. The danger of this, if not immediately detected, with a fire in active operation, will at once be seen. It is, however, by no means an uncommon occurrence where back-pressure valves are omitted, especially where any thickening matter exists in the water, which tends to lift it and cause priming, under which circumstances the water has been found to rush backwards and forwards alternately, between boilers working in connexion. The back-pressure valve prevents this: the water from the feed-pump operating underneath and raising it, while the pressure from the boiler operates on the top and closes it. Necessary as these valves are to the safety of boilers when working in a series, they should not be neglected in the case of those working singly, not only when fed by a pump, but also when fed direct from the water-works main: in the first case, in order that the pump-valves may be accessible when steam is up, and in the second, that the reflux of hot water from the boiler may be prevented, either on the bursting of the pipe or other cause. These valves should be placed immediately upon the shell of the boiler, and not at a distance from it, as is sometimes the case, since scalding might ensue should any joints break in the intervening length of pipe, while repair could not be effected without letting the pressure down. For the same reason the feed-stop valve should not be interposed, which it too frequently is, between the back-pressure valve and the boiler, since a disarrangement of the stop-valve may entail an entire stoppage, which, had the feed back-pressure valve been placed immediately upon the shell, could easily be rectified with steam up.

"In the construction of this valve care should be taken to limit its rise, for want of which simple precaution some of them have proved to be entirely useless, the water passing freely from one boiler to the other, as if the valve was not there. Its most convenient position is at the front end plate of the boiler, nearly on a level with the furnace crown. Its beat can then be heard at every stroke of the engine, and if a screwed spindle be added, so as to convert it into a

combined feed-stop and back-pressure valve, which is the best arrangement, then the feed can be regulated without leaving the furnaces.

"BLOW-OUT APPARATUS.—A case of scalding has lately occurred in consequence of the failure of the blow-out apparatus of a boiler which was, however, not under the inspection of this Association.

"The manner in which blow-out taps are often strained with long levers in opening and closing, renders it a matter of surprise that fracture does not more frequently occur, and many have such inefficient arrangements for carrying off the waste water, that it beats back with so much violence on the taps being opened, that their use is quite dangerous. Enginemen are in this way but too frequently scalded severely, and our own Inspectors sometimes meet with narrow escapes. Some taps are so inconveniently placed that the nut at the bottom of the plug is quite inaccessible, and thus becomes neglected, in consequence of which several cases have occurred of the plug being shot out by the force of the steam on being opened. Taps fitted with glands are safer as well as more convenient; they should, however, be made entirely of brass in the shell as well as in the plug, and be fitted with a suitable waste-pipe. Those made of cast iron in the shell and brass in the plug, are generally found to be inconvenient, and sometimes dangerous, on account of the unequal expansion of the two metals, from which it is frequently impossible to close them, when the boiler becomes robbed of its water, and the fires have to be drawn to prevent injury to the furnaces.

"The case in question, however, was somewhat peculiar, and the fracture did not arise from either of the above causes. The blow-out tap was attached to the boiler by a cast-iron elbow-pipe, and this pipe broke short off without warning, while the boiler was at its regular work and the blow-out tap not being touched.

"The cause of this appeared to be as follows:—Boilers, as has been previously stated in these reports, are too frequently considered to be in a state of rest when once set upon their brickwork bed; whereas, from the constant changes of temperature, and the consequent contraction and expansion that take place not only in the boiler itself, but also in the brickwork, the whole is in a continual state of movement. It appears most probable that this action had, in process of time, induced a slight settlement of the boiler, and thus that a strain was brought upon the cast-iron elbow-pipe, which being bound by the brickwork, consequently gave way. A torrent of hot water naturally ensued, which, unable to escape at the usual outlet, found its way into an adjoining building, where it partially flooded one of the floors, and two or three persons became scalded in consequence.

"PREVENTION OF INCRUSTATION.—It may be stated in brief that the scum-pipes for surface blowing out, which have been recommended from time to time, for the prevention of incrustation in boilers, have now been adopted by several of the members, and have, for some time since, been in very successful operation. An early opportunity will shortly be taken of making more detailed reference to this sub-

ject; but, in the meantime, it may be stated that a drawing of the arrangement adopted lies at the office for the inspection of the members, and that full particulars, both of the details of construction and results of working, will be given on application.

"HINTS TO MEMBERS ON LAYING DOWN NEW BOILERS.—There is one branch of the service which this Association affords, which the members do not avail themselves of as fully as they might—namely, that of consulting the records at the office before laying down new boilers or making alterations. Full particulars are kept, not only of the construction of the boilers under inspection, but also of the results of their working; and a consultation of these would frequently save unnecessary outlay, prevent failures of one being repeated by others, and place at the command of each member the experience acquired by the inspection of the whole number of boilers under the charge of the Association."

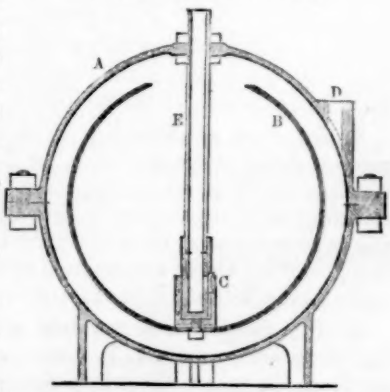
For the Journal of the Franklin Institute.

Furman's Steam Engine Trap.

It is well known that in boilers with large fire surface and but little steam room, heat is transmitted with great rapidity, causing particles of water to be carried over with the steam into the engine, when running with an open throttle; tubular boilers are known to foam more than others, especially those having vertical tubes.

The damaging effects produced by this water of primage, in addition to the natural condensation of the steam-pipe, side-pipe, steam-chest, &c., is obvious. All boilers foam when they contain a mixture of fresh and salt water, and intelligent engineers will not hesitate to avail themselves of a method to separate water from steam, whenever they can be assured that a suitable instrument has been made to accomplish this result.

SECTIONAL VIEW OF TRAP.



The invention of George W. Furman, of New York, is claimed to be the only instrument that has as yet been brought forward that will successfully relieve an engine of the water of condensation and primage. Of this I propose to treat, and herewith annex a sectional drawing of it that will enable the reader to understand its construction and manner of operation:

A, the outside shell; B, the globe or float; C, a slide valve on the stem; D, the passage through which the water enters the trap; and E, the stem through which it is passed off.

When the trap is first set, there is water enough poured into the outside shell A, to float globe B, and close valve C, which will remain

closed, preventing the passing off of either steam or water until the latter has filled the globe and sunk it, when valve C opens, and the pressure of steam forces the water through pipe E. So soon as the water has passed out of globe B, it will rise and valve C close, preventing the passage of steam as before.

The advantages claimed for the use of this instrument attached to an engine are:—

1. *A Decrease of Wear in Packing, Joints, and Springs.*—It is a fact well known that steam will not rust iron, on the contrary, that marks of paint on that metal have been preserved for years where dry steam has been used, but hot water does, and also decomposes rubber, now extensively used for packing, and will pass through openings where steam will not. It is admitted that packing used with dry steam will last much longer than when water is worked through the engine.

2. *An Economy in Lubrication.*—The purpose of lubricating a steam cylinder is to form a polished coating or burnish on its inner surface, that will fill up the irregularities of the metal. This can be accomplished in no better manner than by the rubbing of similar metals together, and would have the desired result if such surface were allowed to remain. With the use of dry steam this would ensue, but the passage of hot water through the cylinder washes off this coating, leaving the interstices to be filled up with particles of water. The evil effects produced by the adulterated substances known as lubricators, may be seen on many engines; the result of their use being to rot the iron leaving it full of small holes, like honeycomb.

3. *A more thorough Condensation with less Injection Water.*—Dry steam passing from the cylinder to the condenser, requires a certain amount of cold water to reduce its temperature to 100°, which is near the average heat of water discharging into the hot-well. If, then, in addition to this steam, there be an increased amount of primage water, or that of condensation at 212°, carried into the condenser, it is evident that a larger quantity of cold water will be required to reduce the whole to the required temperature, in which case more work is demanded of the air-pump, and thus power is lost.

4. *No need of Blowing through an Engine to Warm it.*—This point is easily dispensed with, as the work is always done by the trap, which is at all times in operation, whether the engine is moving or standing still; consequently, when there is enough steam in the boiler, the engineer can at once start the engine. When the discharge-pipe is not carried above the connexion with the engine, the weight of the water alone will work the instrument without the aid of steam.

5. *The Engine will not heat while lying still.*—Engines become hot while not in motion, in consequence of the condensed steam passing from the steam-chest into the condenser. That this is effectually prevented by the attachment of the trap, is proven by the fact that the steamer *Flushing*, while in the service of the Government, lay at anchor seven consecutive days, without "turning over" her engines.

The report of the engineer of this vessel is annexed, that this point may not be disputed.

Few engineers fully realize the quantity of water that passes through their engines when their boilers foam, and when the amount is shown them after it has been carried through this instrument, the majority of them have claimed that the greater portion of it is condensed by the instrument itself.

To dispose of this question, in a measure, the reader's attention is asked to the subjoined extract from an official report to the Secretary of the Navy, by B. F. Garvin, Esq., Chief Engineer of the Brooklyn Navy Yard, under date of December 16, 1862:—

"At the end of about two hours, no more water made its appearance. About two gallons of water came from the trap at first, but after half to three-quarters of an hour, it ceased running entirely. I consider the boat was well adapted for the purpose, having the engine at one end and the boiler at the other, necessitating a long steam-pipe, which presented a large surface for condensation."

That the reader may fully understand the merits of the extract just quoted, it is stated that a ferry-boat, plying upon the East River, between New York and Brooklyn, was "laid up" at half-past six o'clock, P. M., and precisely one hour after, Mr. Garvin commenced the experiment, the result of which is given, and worked the engine in the time named in his report. During the period of the experiment the furnace doors were open, the feed on, with 20 lbs. of steam, the throttle-valve partly shut off, and the engine making but 10 revolutions per minute. If then, under these circumstances, the most favorable for condensation, the steam-pipe 40 feet long, engine and side pipe 9 feet long, and cylinder 36 inches in diameter, condense only two gallons of water in as many hours *with* the trap attached, it can be easily estimated how much of that condensation is due to its agency.

On February 28, 1863, experiments were made on the engine of the steamboat *Louise*, running between Hunter's Point, L. I., and Thirty-fourth street, New York, which were conducted by Messrs. George P. Hunt and Benjamin Wood, U. S. N., (detailed for the purpose by Chief Engineer, B. F. Garvin, U. S. N.,) and other Engineers of reputation. The experiments were continued two hours, one with the trap attached, and one without, making four trips to each experiment, across the East River with a strong ebb tide, using the same throttle and injection, with the following results:—

WITH THE TRAP.

	First Trip.	Second Trip.	Third Trip.	Fourth Trip.
Steam upon starting, lbs.	24	25	24	25
" at end of experiments, lbs.	13	13	14	15
Vacuum, inches,	26	26	26	26
Revolutions per minute,	26½	27	27	26
Time per trip, minutes,	4¾	5	4¾	6
Average Steam,			19·12 lbs.	
" Vacuum,			26· ins.	
" Revolutions,			26·62 per min.	
" Time per trip,			5·12 minutes.	

WITHOUT THE TRAP.

	First Trip.	Second Trip.	Third Trip.	Fourth Trip.
Steam upon starting, lbs.	27	25½	26	26½
" at end of experiments, lbs.	15	16	13	15½
Vacuum, inches,	23	25	25	22
Revolutions per minute,	24	23½	24	23½
Time per trip, minutes,	7½	7	7½	7

Average Steam, 20·56 lbs.
" Vacuum, 23·75 ins.
" Revolutions, 23·75 per min.
" Time per trip, 7·25 minutes.

NOTE.—During the first hour, while the engine was running with the trap, seventy-five measured gallons of water passed through it.

These experiments were made to demonstrate the utility of the instrument with a foaming boiler, three solid cocks of water being carried during the entire time the experiments were continued; whilst the following report of the Engineer of the same steamboat, running upon the same route, of experiments made under his personal supervision, were made to illustrate its value when every thing was in the ordinary running condition:

The experiments were commenced on the morning of March 2d, 1863, and were intended to have continued three days with the trap, and the same period without it. An abstract of the three days with the instrument is given, and but two days without it, as the globe cock (used for shutting off the trap from the lower end of the cylinder), became so much injured by the pressure of water behind it, that the trap could not be shut off, and the experiment was abandoned on the morning of the 7th inst.

WITH THE TRAP.

March 2.—Made 40 trips. Running time, 3 hours, 18½ minutes. Average steam, 15·62 lbs. Do. time, 4·96 minutes.

March 3.—Made 39 trips. Running time, 3 hours, 7½ minutes. Average steam, 19·94 lbs. Do. time, 4·81 minutes.

March. 4.—Made 37 trips. Running time, 2 hours, 51½ minutes. Average steam, 16.14 lbs. Do. time, 4·63 minutes.

NOTE.—Burning eleven loads of coal, of 900 lbs. each; tallow was used in the cylinder four times, and the vacuum gauge showed 26 inches.

WITHOUT THE TRAP.

March 5.—Made 39 trips. Running time, 3 hours, 27½ minutes. Average steam, 15·20 lbs. Do. time, 5·32 minutes.

March 6.—Made 36 trips. Running time, 3 hours, 15 minutes. Average steam, 15·35 lbs. Do. time, 5·42 minutes.

NOTE.—Burning eight loads of coal, of 900 lbs. each; tallow was used eight times, and the vacuum gauge showed 25 inches.

Annexed will be found the reports of Henry C. White, Eng. of the *Flushing*, Robert H. Spears, Chf. Eng. of the Houston Street Ferry Co., and James M'Farlan, Chf. Eng. of the Union Ferry Co., New York, to Mr. G. W. Furman, which are of interest, as detailing their experience of the workings of this instrument.

Steamer Flushing, New York, May 5, 1862.

DEAR SIR:—I have used your engine trap on the steamer *Flushing* for six months past, and am prepared to speak of its merits. The *Flushing* is a river steamer, with a beam engine, 36-inch cylinder, and ten feet stroke, whose boiler was constantly foam-

ing, and as a consequence I was obliged to use a large amount of tallow in her cylinder. During thirty days previous to attaching your trap, the amount of tallow used was 229 lbs., and during a subsequent thirty days, with the trap, only 30 lbs. were used. As no alteration had been made in the engine in the way of repairs, I attribute the difference in the quantity of tallow used to the presence of dry steam. During the time I had no trap I was troubled with "primage," but while using it I found the engine relieved of that trouble, as I could run with the "throttle" wide open, with high steam, without any water passing into the cylinder. I also found that in using the trap I did not require so frequent a renewal of the packing around the piston-rod, valve stems, &c., which I also attribute to the use of dry steam; and I also found an economy of 8 per cent. in coal in using the trap.

During the month of March the *Flushing* was chartered by the Government as a transport vessel, and then I found it a great advantage that the engine was always free of water and ready to start; the trap rendering it unnecessary to "blow through," or "warm up," before starting—as was proved, when, on one occasion, I lay for seven days with steam up, and did not touch the engine until the bell rang to start.

The water taken from the steam-chest by the trap was discharged into a tank on deck, which provided all the hot fresh water that was wanted for use in washing, scrubbing the paint-work, and in the kitchen, &c. While carrying troops, the hot water used by them for making coffee alone, averaged 435 gallons per day, by actual measurement. The Quartermaster, on being informed of this fact, directed the Captain of the boat to turn off twelve water casks, and to run with that number less than the regulations called for, for the use of the troops—the deficiency being supplied by the trap.

This is a plain statement of facts, which you are at liberty to use as you please. It is my opinion that the use of your trap will guarantee dry steam, economy of fuel, economy of lubrication in cylinders, and durability of packing, and that to insure these results, it is indispensable.

(Signed) HENRY C. WHITE, Engineer.

Houston Street Ferry Company, Williamsburgh, Sept. 3, 1861.

DEAR SIR:—At your request I give you a statement of the working of your traps, as applied to the boats on our ferry.

The first trap put up by you was attached to the *Gerard Stuyvesant*, December 31, 1860, which proved so satisfactory that they were ordered on the *City of Williamsburgh* and *California*, April 15, 1861.

They have all worked to my entire satisfaction, requiring no care or attention.

I have to report:

Increase of speed, the engines making more turns than ever before.

A saving of fuel.

Decrease of wear and tear on packing, joints, and springs of engines.

Relief to air-pump, by decreasing the load of water formerly discharged.

A certainty of dry steam in the engine, and a more thorough condensation.

Dispensing with the necessity of "blowing through" the engine, when about to start in the mornings.

A saving of oil for cylinder; a pint per boat being the allowance per day.

A return of water from engine, with what oil may pass with it, to the tanks for feeding the boiler.

The impossibility of the engine becoming hot, while lying in the slip, which was of frequent occurrence before the traps were attached.

As a substitute for a priming or snifting valve, I can heartily recommend it, as, from its simplicity of construction, it cannot well get out of order; it is self-acting, and only requires for its welfare to be let alone.

They are also attached to the four boats of the East River Ferry Company, at Hunter's Point, with equal success.

(Signed) ROBERT H. SPEARS, Chief Engineer.

Office of Union Ferry Co. of Brooklyn, February 26, 1863.

DEAR SIR: Your Steam Traps attached to the engines of our ferry-boats, fifteen in number (two vertical beam, the balance inclined), have given perfect satisfaction, and have accomplished all you promised, when you put up the first one in December, 1861.

The beneficial results are: an economy of tallow, *equal to* FORTY *lbs. per week, for each boat, or a saving of over* SEVENTY-FIVE *per cent. of the amount formerly used.*

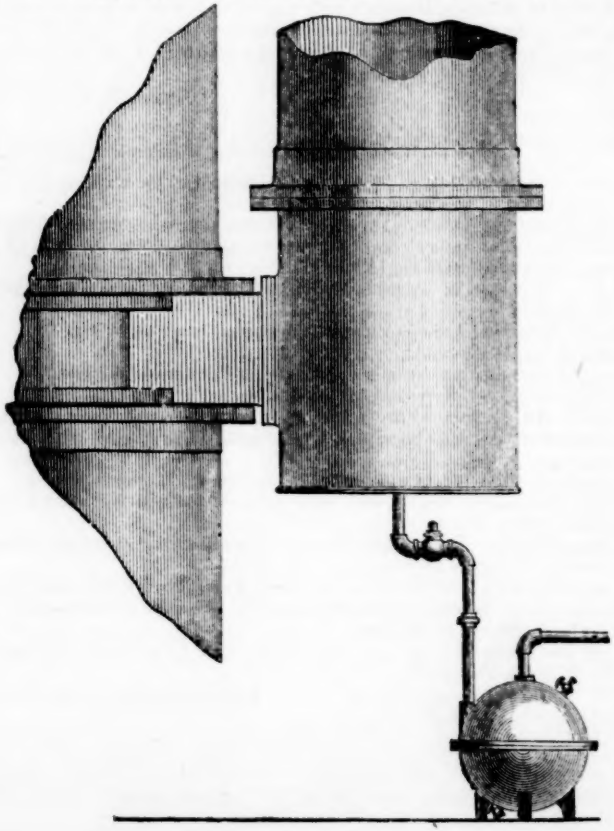
An increase of speed, on account of being able to leave the bridge at full speed, therefore getting the boat well under way, before leaving the slip, and also by relieving the condenser and air-pump of the water of condensation and primage, and the additional injection-water required to cool it, and the consequent saving of fuel. As the engine is at all times free of water, the necessity of blowing it off is avoided, and there is never any danger arising from its collection in the cylinder. The packing, I find, lasts much *longer than formerly.* The water, as taken from the engine, is passed into the tanks for feeding the boiler.

Forty-seven years experience as a Steam Engineer, qualifies me to judge of its merits, and I do not hesitate to recommend it as a very valuable attachment to *any* engine.

(Signed,) JAMES MCFARLAN, *Chief Engineer.*
For the Union Ferry Company.

That the manner of attaching the trap to the steam-chest of a vertical engine may be understood, I herewith annex a cut of its attachment:

TRAP AS ATTACHED TO STEAM-CHEST OF VERTICAL ENGINE.



DIRECTIONS FOR USING THE TRAP.

When this instrument is attached to an engine, the check-valves must be placed horizontally, so that the water will flow freely through them. The same end of the valve that is placed next to the pump for feeding the boiler, must be placed nearest to the flow of water from the engine.

It requires to be so far filled with water, before first getting up steam, that globe B will float. If, by any accident, the slide-valve C becomes obstructed, and the steam blow through, it will be necessary to add sufficient water to again float globe B, which may be done by closing the cocks in the connexions, so far as to permit the water to pass into the trap in small quantities, or by pouring it through the hand-hole.

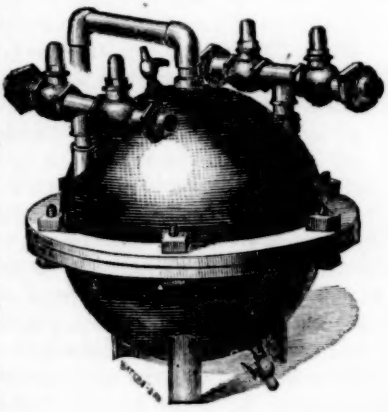
Before starting the engine, after lying idle several hours, open the air-cock on the top of shell A, and let it remain open until the air collected in the engine has passed through it.

The valves connecting the trap with the engine *should always be open*.

When much lubrication is resorted to in the cylinder, the check-valves may occasionally require to be cleaned of gum or grease. If, from the same cause, the slide-valve C becomes obstructed, it may be relieved by putting a small quantity of potash in globe B. So, too, if there ever be an accumulation of grease in shell A, it can be cleaned in the same manner. The trap can be relieved of dirt by removing the bonnet from the lower hand hole, and blowing steam through it.

Locomotive Engines.—This instrument is well adapted for relieving the cylinders of locomotive engines of water. As the boiler of a locomotive has large fire-surface and but little steam-room, primage must necessarily be of frequent occurrence. It is claimed by its inventor that its attachment to this character of engines will show an economy of fuel, an increase of speed, a removal of back pressure from the piston, by carrying off the water and allowing only dry steam to pass through the blast-pipe, an economy of oil in lubrication of cylinders, and a saving of packing. We herewith annex a cut illustrating the manner of its attachment to these engines.

TRAP FOR ATTACHMENT TO LOCOMOTIVE ENGINES.



In conclusion, I would add that this instrument has been successfully applied to the engines of the following steam vessels:—

Steamboats *Flushing*, *Broadway*, *Anna*, *City of Albany*, and twenty-seven others, plying between New York and Long Island, and New York and Jersey City.

Propellers *Falcon*, *Thomas Foulks*, and *Sze-Chuen*.

Steamers *Vixen*, *Corwin*, and *Hu-Quang*.

Steamships *Salvador*, *Matanzas*, *Parkersburgh*, and *Ta-kaing*.

Total, 41 steam vessels. B.

Signals to Prevent Collisions at Sea.

From Mitchell's Steam Shipping Jour., April, 1863.

BOARD OF TRADE, Jan. 12, 1863.

1. By virtue of the "Merchant Shipping Act Amendment Act, 1862," and of an Order in Council, dated 9th January, 1863, the following Regulations, containing certain verbal Amendments, are substituted for the Regulations contained in the Schedule to the Act.

2. The following Regulations come into operation on the 1st of June, 1863.

3. The following Regulations apply to all Ships, whatever their Nationality, within the limits of British Jurisdiction, and to British and French Ships whether within British Jurisdiction or not.

4. The Order in Council containing these Regulations is published in the *London Gazette* of the 13th January, 1863.

T. H. FARRER, Assistant Secretary,
Marine Department.

Preliminary.—Article 1. In the following Rules every steamship which is under sail and not under steam is to be considered a sailing ship; and every steam ship which is under steam, whether under sail or not, is to be considered a ship under steam.

Rules Concerning Lights.—Art. 2. The lights mentioned in the following Articles, numbered 3, 4, 5, 6, 7, 8, and 9, and no others, shall be carried in all weathers from sunset to sunrise.

Art. 3. Sea-going steamships when under way shall carry:

(*a*) *At the Foremast Head*, a bright white light so fixed as to show a uniform and unbroken light over an arc of the horizon of 20 points of the compass; so fixed as to throw the light 10 points on each side of the ship, viz: from right ahead to 2 points abaft the beam on either side; and of such a character as to be visible on a dark night with a clear atmosphere at a distance of at least five miles:

(*b*) *On the Starboard Side*, a green light so constructed as to throw a uniform and unbroken light over an arc of the horizon of 10 points of the compass; so fixed as to throw the light from right ahead to two points abaft the beam on the starboard side; and of such a character as to be visible on a dark night with a clear atmosphere at a distance of at least two miles:

(*c*) *On the Port Side*, a red light, so constructed as to show a uniform and unbroken light over an arc of the horizon of 10 points of the compass; so fixed as to throw the light from right ahead to 2 points abaft the beam on the port side; and of such a character as to be visible on a dark night with a clear atmosphere at a distance of at least two miles.

(*d*) The said green and red side lights shall be fitted with inboard screens projecting at least three feet forward from the light, so as to prevent these lights from being seen across the bow.

Art. 4. Steamships when towing other ships shall carry two bright

white mast-head lights vertically, in addition to their side lights, so as distinguish them from other steamships. Each of these mast-head lights shall be of the same construction and character as the mast-head lights which other steamships are required to carry.

Art. 5. Sailing ships under weigh or being towed shall carry the same lights as steamships under weigh, with the exception of the white mast-head lights, which they shall never carry.

Art. 6. Whenever, as in the case of small vessels during bad weather, the green and red lights cannot be fixed, these lights shall be kept on deck on their respective sides of the vessel ready for instant exhibition; and shall, on the approach of or to other vessels, be exhibited on their respective sides in sufficient time to prevent collision, in such manner as to make them most visible, and so that the green light shall not be seen on the port side, nor the red light on the starboard side.

To make the use of these portable lights more certain and easy, the lanterns containing them shall each be painted outside with the color of the light they respectively contain, and shall be provided with suitable screens.

Art. 7. Ships, whether steamships or sailing ships, when at anchor in roadsteads or fairways, shall exhibit, where it can best be seen, but at a height not exceeding twenty feet above the hull, a white light in a globular lantern of eight inches in diameter, and so constructed as to show a clear, uniform, and unbroken light visible all around the horizon, and at a distance of at least one mile.

Art. 8. Sailing pilot vessels shall not carry the lights required for other sailing vessels, but shall carry a white light at the mast-head visible all around the horizon, and shall also exhibit a flare-up light every fifteen minutes.

Art. 9. Open fishing boats and other open boats shall not be required to carry the side lights required for other vessels; but shall, if they do not carry such lights, carry a lantern having a green slide on the one side and a red slide on the other side; and on the approach of or to other vessel such lantern shall be exhibited in sufficient time to prevent collision, so that the green light shall not be seen on the port side, nor the red light on the starboard side.

Fishing vessels and open boats when at anchor, or attached to their nets and stationary, shall exhibit a bright white light.

Fishing vessels and open boats shall, however, not be prevented from using a flare-up in addition, if considered expedient.

Rules Concerning Fog Signals. Art. 10. Whenever there is fog, whether by day or night, the fog signals described below shall be carried and used, and shall be sounded at least every five minutes, viz:—

(*a*) Steamships under weigh shall use a steam whistle placed before the funnel not less than eight feet from the deck.

(*b*) Sailing ships under weigh shall use a fog horn.

(*c*) Steamships and sailing ships when not under weigh shall use a bell.

Steering and Sailing Rules.—Art. 11. If two sailing ships are meeting end on or nearly end on so as to involve risk of collision, the helms

of both shall be put to port, so that each may pass on the port side of the other.

Art. 12. When two sailing ships are crossing so as to involve risk of collision, then, if they have the wind on different sides, the ship with the wind on the port side shall keep out of the way of the ship with the wind on the starboard side, except in the case in which the ship with the wind on the port side is close-hauled and the other ship free, in which case the latter ship shall keep out of the way; but if they have the wind on the same side, or if one of them has the wind aft, the ship which is to windward shall keep out of the way of the ship which is to leeward.

Art. 13. If two ships under steam are meeting end on or nearly end on so as to involve risk of collision, the helms of both shall be put to port so that each may pass on the port side of the other.

Art. 14. If two ships under steam are crossing so as to involve risk of collision, the ship which has the other on her own starboard side shall keep out of the way of the other.

Art. 15. If two ships, one of which is a sailing ship and the other a steamship, are proceeding in such directions as to involve risk of collision, the steamship shall keep out of the way of the sailing ship.

Art. 16. Every steamship, when approaching another ship so as to involve risk of collision, shall slacken her speed, or, if necessary, stop and reverse; and every steamship shall, when in a fog, go at a moderate speed.

Art. 17. Every vessel overtaking any other vessel shall keep out of the way of the said last mentioned vessel.

Art. 18. Where by the above rules one of two ships is to keep out of the way, the other shall keep her course subject to the qualifications contained in the following Article.

Art. 19. In obeying and construing these Rules, due regard must be had to all dangers of navigation; and due regard must also be had to any special circumstances which may exist in any particular case rendering a departure from the above Rules necessary in order to avoid immediate danger.

Art. 20. Nothing in these Rules shall exonorate any ship, or the owner or master or crew thereof, from the consequences of any neglect to carry lights or signals, or of any neglect to keep a proper lookout, or of the neglect of any precaution which may be required by the ordinary practice of seamen, or by the special circumstances of the case.

For the Journal of the Franklin Institute.

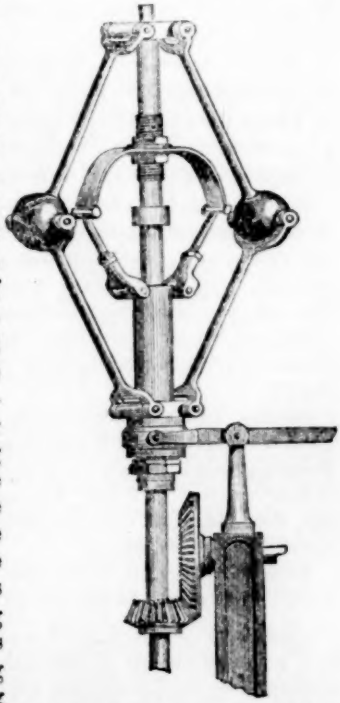
Description of Jenkins and Jumelle's Governors for Steam Engines.

By H. Howson.

This invention by C. C. Jenkins and F. Jumelle of Philadelphia, consists in combining with a governor or spindle, a spring and rods arranged to form a knee joint, in the manner hereafter described, so that the force applied to overcome the rigidity of the spring, may

be transmitted through a leverage constantly increasing as the resistance of the spring increases, thereby equalizing the action of the spring.

The weighted arms of the governor are hung to the top of the spindle in the usual manner. To the weights of the arms are jointed the upper ends of rods, the lower ends of the latter being connected to a sleeve which is fitted snugly to, but arranged to slide freely on, the spindle. A spring is connected at a point midway between its opposite ends, to the spindle by means of nuts, which are adapted to the screwed portion of the said spindle. To one end of the spring is jointed a rod, and to the opposite end a similar rod, one rod being connected to a lug on one side, and the other to a lug on the opposite side of the upper end of the sleeve. The lower end of the latter has a recess for receiving the end of the usual governor lever through which the movement of the sleeve is communicated to the throttle valve of the steam engine. This recess formed by two collars, one of which is fast to the sleeve, the other being screwed on to the same, as is also a nut, the striking of which against a nut screwed on to the spindle, limits the downward movement of the sleeve, and consequently, the inward movement of the weights.



The sleeve is illustrated in the Figure as depressed to the limit of its downward movement, as regulated by this nut. As the governor revolves the weighted arms will fly out, and the sleeve will rise to an extent regulated by the speed of the governor, and the rigidity of the spring. Now supposing this spring acted directly on the sleeve without the intervention of the rods, it will be evident that the higher the sleeve rises through the centrifugal force of the weights, the greater will be the opposing force presented by the increased rigidity of the spring as the opposite ends of the latter are raised, consequently the governor will be irregular in its movement, the irregularity being in proportion to the difference of the rigidity of the spring as the ends of the latter are raised. By connecting the spring to the sleeve by means of the rods, however, the case is different, as they form with the sleeve and spring the well known knee-joint, so that, as the sleeve is raised, it acts on the spring through a leverage, gradually increasing as the sleeve rises, and as the rigidity of the spring increases. Thus when the sleeve is depressed to the limit of its downward movement,

the force exerted by the revolving balls tending to raise the ends of the spring, will be applied, as it were, through a lever of which the fulcrum is at a point near the centre, while as the spring rises, this fulcrum gradually approaches the farther end of the lever giving an increased leverage as the rigidity of the spring increases.

It will be evident that by transmitting the force imparted to the sleeve by the action of the revolving weights, to the spring through the medium of a knee-joint; the increasing rigidity of the spring as its opposite ends are raised, is counteracted by an increase in the force applied to raise the said ends, and consequently, that the action of the governor is uniform throughout.

For the Journal of the Franklin Institute.

Description and Trial Trip of the Steamship Continental.

In the early part of the year 1862, the Ocean Steam Navigation Company asked proposals of the marine engine builders of this city for a propeller engine, competent to develop the same power as that of their paddle wheel steamship, *Keystone State*, whose cylinder has a bore of 80 inches, and length for 8 feet stroke; number of revolutions, 15 per minute with a steam pressure of 22 lbs., cut-off at one-half the stroke.

At the same time, proposals were given for the hull, to be built from the designs of Mr. J. W. Griffith, naval architect.

The contracts were awarded to Messrs. Merrick & Sons for the engine, and to Mr. J. W. Lynn for the hull. The following are the principal dimensions of both:—

Hull.—Length for tonnage, 238 ft. 6 ins. Do. for deep load-water line, 221 ft. 7 ins. Breadth of beam at midship section, 38 ft. Depth of hold, 16 ft. Length of engine and boiler space, 33 ft. Length of shaft, forward of stern post, 76 ft. Draft of water at deep load line, 12 ft. Draft of water at below pressure and revolutions, 11 ft. forward, 11 ft. 6 ins. aft. Area of immersed section at 12 ft. draft, 390 sq. ft. Masts and rig, schooner.

Engine.—Diameter of cylinder, 50 ins. Length of stroke, 3 ft. 9 ins. Maximum pressure of steam in pounds, 35 lbs. Cut off, $\frac{3}{4}$ stroke. Maximum revolutions per minute, 56.

Boilers.—Two. Length of boilers, 12 ft. Breadth or face, 20 feet. Number of furnaces in each, 6. Breadth of furnaces, 2 ft. 9 ins. Length of grate bars, 6 ft. 8 ins. Number of flues or tubes in each, 336. External diameter of flues or tubes, 3 ins. Length of flues or tubes, 7 ft. 6 ins. Heating surface, total, 4860 sq. ft. Diameter of smoke-pipe, 6 ft. Height, do. 40 ft. Description of coal, anthracite. Draft, natural. Consumption of coal per hour, $1\frac{1}{2}$ tons.

Propeller.—True screw. Diameter, 12 ft. 6 ins. Length of Blades, fore and aft, 2 ft. 6 ins. Pitch, 24 ft. Number of blades, 4. Average revolutions per minute, 52.

Remarks.—Fitted with a surface condenser; also, with J. V. Merrick's patent double ported balanced slide valve, and with a small slide valve for warming up and starting the engine. Independent fire and bilge pump. Independent engines for hoisting cargo, and also the ashes from the fire room upon a labor saving plan devised by Mr.

Alexander Heron, Agent of the Company. Mr. Heron also arranged coal bunks from the upper deck downwards so as to cause nearly their entire contents to run towards the bunker doors by gravity, thus dispensing with the coal passers. Fifty tons of coal are carried in bunks built over the boilers, intended as a reserve to be used in an emergency.

The following is an account of her first performance, which took place November 26th, 1862.

Trial Trip of Steamer CONTINENTAL, *November 26th*, 1862.

	Time. h. m.	Steam.	Vacuum.	Revolutions.	Throttle.	Tide.	Wind.	
Navy Yard,	10 48	20½	22	44	Wide	Ebb.	Abeam.	
Point House,	11 9½	20½	22	44	"	"	Starboard bow	
Fort,	11 35	24	20½	48	"	"	" "	
Chester Pier,	12 16	26	20½	52	"	"	" "	
Within ¼ mile of Brandywine light,	1 42	32	20	52	¾	Flood.	Port Quarter.	Stopped 8 minutes to avoid several vessels in the channel.
Marcus Hook,	2 16	29½	22	51	½	"	Abeam.	Rounded to and started up the river.
Chester,	2 31½	29½	22	51	¾	"	"	
Fort,	3 7	30	21½	54	¾	"	"	
Navy Yard,	3 36	34½	21	56	Wide.	"	Ahead.	

By taking the distance from Marcus Hook to the Navy Yard, the longest distance run between measured points made without a stop, at 20¼ miles, and allowing 2½ miles per hour for the tide and dividing by the time, we will have speed of ship through the water in miles per hour, thus:—

$$\frac{20{\cdot}25 - 2{\cdot}5}{3{\cdot}36 - 2{\cdot}16} = 13{\cdot}3125 \text{ miles.}$$

The wind, being unfavorable, retarded the ship somewhat, as she was very high out of the water; and the speed in calm weather through the water would most likely be about 13½ miles, and might exceed that if she were loaded so as to immerse the whole of the propeller, which, it will be seen, was fully $_1{}'_2$ its diameter above the water. The trial was satisfactory to all concerned; the time occupied in running between certain points was almost identical with that of the *Keystone State* on her trial, as:—from Marcus Hook to Chester, 30 seconds less; and, from Chester to Navy Yard one minute more. The two hulls had about the same immersed section which shows that the engine of the *Continental* came up to the requirements of the contract.

The balanced slide valve worked admirably; one man being able to shift with ease, the slot link from ahead to backing point by means of a 34-inch hand wheel upon the same shaft with a 4-inch pinion, working into a rack attached to the link. The valve is 34 ins. wide by 38 ins. long. Steam of the before mentioned tension when pressing upon an unbalanced valve of this size exerts a force $=34 \times 38 \times 34\frac{1}{2}$ lbs. $=44574$ lbs. and as friction of cast iron upon cast iron when lubricated

is about $\frac{1}{10}$th total weight, or pressure on surfaces, we have 4457 lbs. required to move the valve. The entire motion of the valve is 7 ins. and the power required to work it (still supposing it to be unbalanced) would be at 56 revolutions of engine $\frac{4457 \times \frac{7}{12} \times 2}{33000} = 8{\cdot}82$ horses.

An examination of the valve after two voyages had been made from New York to New Orleans and back, and one voyage from Philadelphia to New York and back showed that nothing better, as a balanced slide valve need be desired, the rubbing surfaces being polished like mirrors.

Messrs. Merrick & Sons applied this balanced valve to the engines of U. S. Steamer *New Ironsides*, and are about to place it on those of U. S. Steamer *Yantic* and Ram *Tonawanda* now building at their works. J.

For the Journal of the Franklin Institute.

Particulars of the Ship Cremorne.

Hull built by Maxson, Fish & Co., Mystic, Conn. Commander, Capt. Isaac D. Gates. Intended service, California and East India Trade. Owners, Lawrence, Giles & Co., New York.

Hull.—Length over all, 200 ft. Breadth of beam, 39 ft. Depth of hold, 14 ft. Do. between decks, 9 ft. Half poop, including mainmast, 4½ ft. Keel, 15 by 24 ins. Frames—molded, 17 ins. Bilge strakes, 12 ins., diminishing to 8 ins. Lower deck beam, 15 by 15 ins. Main deck, do., 14 by 12 ins. Garboard strake, 6 ins. Bottom planking, 4 ins. Wales, 5 ins. Tonnage, 1413 tons.

Masts, &c.—Foremast, 74 ft. Diameter of do., 31 ins. Mainmast, 77 ft. Diameter of do., 32 ins. Mizzen-mast, 70 ft. Diameter of do., 25 ins. Topmasts, 46 ft. Lower Yards, 72 ft. Lower Topsail Yards, 63 ft. Upper do., 50 ft.

Remarks.—This vessel is well built, and in every respect thoroughly and heavily fastened with composition spikes, copper butt bolts, and treenails. Her keel is of white oak, also her keelsons of three thicknesses, all edge-bolted. Her frames are of white oak and white chestnut, very heavy; ceiling, white oak, beams and deck frame, white chestnut, all full kneed with hacmetac and oak knees; clamps are edge-bolted; patent windlass. Has six hooks and pointers forward, and same number aft. Launched, March 19th, 1863. B.

For the Journal of the Franklin Institute.

Speed of Ships.

The Barque *Nelly* of New Castle, Del., 506 tons burthen, belonging to Mr. J. C. Brooks of that place, recently made the passage from New York to Sligo in 18 days. When it is considered she contended with easterly winds, and the vessel was deeply laden with grain, this passage is extraordinary. It has rarely been equalled, much less surpassed.

The Clipper Ship *Daring*, Capt. Simonson, made the run recently from New York to Liverpool in 19 days. Her outward passage to Liverpool was made in 17 days—thus making the round voyage in 36 days.

The Clipper Ship *Snow Squall*, of New York, left Sandy Hook at noon, December 2d, 1862, and arrived at Melbourne, Australia, February 16th, 1863, making the passage from port to port in 75 days.

The Clipper Ship *Dacon*, Capt. Chase, has made the passage from Buenos Ayres to New York in 38 days.

The Steamer *Columbia*, of New York, left the Navy Yard, Washington, May 11th, 1862, and arrived at her dock, East River, in 30 hours—the shortest run between these points on record.

The Steamer *Baltic*, of New York, left Annapolis, Md., April 24th 1862, and arrived at her dock, East River, in 29 hours. B.

Solid Drawn Gun Barrels.

From the London Practical Mechanic's Journal, Jan., 1863.

On the 1st December, 1862, by the permission of the Court of the Gunmaker's Company, some very interesting experiments were made at the proof-house, Whitechapel, London, on a fowling piece and rifle barrel made by the new process of solid cold-drawing, of which Messrs. Christoph, Harding, and Hawksworth are the patentees. By this process the metal is drawn cold, by means of the hydrostatic press, and thus a saving is effected to the extent of one-half the metal now consumed by the hot process. For instance, about 10 lbs. of metal is now used in making an Enfield rifle barrel, which, when made, weighs only 4¾ lbs., the remainder of the metal being consumed in the manufacture. By the present process two rifle barrels can be drawn from the same amount of metal, equally strong in every respect to those now made. The barrels tried were drawn from a new kind of cast steel, and subjected to the following proofs:—

Rifle Barrel.

First proof, 7½ drachms of powder, 2 wads and 1 ball of 520 grains,	No injury.
Second, Same powder and 2 balls,	"
Third, 10 drachms of powder and 3 balls,	"
Fourth, 15 drachms of powder and 5 balls,	"

The smooth bore was put to the following proofs:—

First proof, 10¾ drachms of powder, 2 wads and 1 round ball of 24 to the pound,	No effect.
Second, Same powder, 2 wads and 2 round balls,	"

It was then determined to burst this barrel by putting in a proof charge and two balls, and filling the muzzle of the barrel to the extent of two inches with moist clay. The result was, that the barrel burst at the bottom of the clay, only tearing about two inches of its length, and showing no other signs of injury. A similar barrel, proved

at Birmingham, only slightly bulged, with 20 drachms of powder and 3 balls.

Several specimens were also exhibited, showing the applicability of this process to drawing hollow tubes in iron or steel of any shape, and almost any reasonable length. At present we understand it has not been applied to tubes of more than 1⅜ inches diameter, or to a length exceeding 30 feet. Its extension to larger tubes is evidently a mere question of mechanical power. The patentees estimate that by the adoption of their process the cost of iron gun barrels will be reduced to one-third the present price, and that a cast steel barrel can be supplied at the present cost of an iron one.

That a very great increase of cohesive strength *in the longitudinal direction* is produced by the forcible extension, either by rolling or by drawing (and whether cold or hot) wrought iron, has long been known.

In the case of fine iron wire, such as pianoforte strings, the increase of ultimate longitudinal strength is quite surprising, being as much frequently as an increase of from 30 tons per square inch ultimate strength in the original forged or rolled slab from which the wire is to be drawn, up to 120 tons per square inch in the wire itself. The nature of the molecular changes produced by this powerful compression laterally and extension longitudinally of the crystals of the iron has been pointed out by Mr. Mallet, in his work on the Physical Properties of the Metals for Artillery, &c., and shown to result from his law—"That in all crystallizable solids the principal axes of symmetry of the integrant crystals, tend to place themselves at right angles to the direction of greatest pressures within the mass"—which is in a drawn or rolled rod longitudinally, *i. e.*, at right angles to the pinch of the drawplate or rolls. It is in virtue of this that the hot rolled rod of rivet iron, is stronger and tougher longitudinally than the lump out of which it is rolled, and if a piece of this hot rolled rivet rod be cut off, and drawn out into fine wire, its strength and toughness will be still further exalted.

If the rod be rolled cold, the same result proportionally to the pressure and mass follows. This effect of cold rolling on iron was announced some few years since as quite a new discovery, and Mr. Fairbairn made some experiments on the increase of strength conferred. If the bar or the wire be heated red hot however, and cooled suddenly, or be slowly annealed, though some increase of strength remains, a great deal of the increased strength is found again to have been lost.

There is no doubt whatever that a cold drawn gun barrel, therefore, will have a very high amount of longitudinal strength, but it by no means follows that any like increase of strength as against bursting by the charge of powder, through circumferential strains, or any increase *at all*, as respects this, shall result.

If a rod forged in a twisted set of spirals like a twist barrel, were drawn or rolled cold, and after its extension would bear further forcible cold twisting in the same direction, we think it not improbable that some increment of strength as against bursting might be obtained, though we say this with reserve; but if so, this would not survive the

rods being annealed. Any rod or barrel thus treated, or drawn or rolled cold, has its particles thrown into tensions and internal strains, which, at every particle cut off, either from the outside or the inside, by filing or boring, &c., will cause the whole mass to alter its shape by twisting or bending spontaneously. In fact, this actually takes place now in the Enfield forged barrels inevitably, to a sufficient extent, to make final straightening by the hammer necessary. Of course, the same may be done with cold drawn barrels, but the internal strains will be far more vehement, and we apprehend such barrels might show a persistent tendency to return to a crooked form.

However, the method presents other advantages in point of economy, &c., which are in no way problematical; and we should be greatly pleased to see some really well devised experiments made by water pressure, upon cold drawn and upon hot rolled barrels from the same iron, as to their relative bursting resistances, a question which, certainly, the preceding experiments do not solve.

Our remarks are not meant as condemnatory of the proposed method, nor even as discouraging, we but wish to place in contact with what is proposed, the ascertained facts of metallurgy already known.

For the Journal of the Franklin Institute.

Notes of Shipbuilding and the Construction of Machinery in New York and vicinity.

(Continued from p. 179.)

The Steamer Falcon.—Hull built by Charles H. Mallory, Mystic, Conn. Machinery constructed by C. H. Delameter, New York. Route of service, New York to Providence. Owners, Commercial Steamboat Co.

Hull.—Length on deck, 160 ft. Breadth of beam, 34 ft. 6 ins. Depth of hold, 11 ft. Do. to spar-deck, 18 ft. Draft of water, 11 ft. Frames—molded, 13½ ins.—sided, 8 ins. apart at centres, 24 ins. Tonnage, 875 tons.

Engines.—Vertical direct. Diameter of cylinders, 30 ins. Length of stroke of piston 3 ft.

Boilers.—Two—tubular—located in hold, and use blowers to furnaces.

Propeller.—Diameter, 11 ft. 6 ins. Blades, 4. Material, cast iron.

Remarks.—This steamer is of white oak and chestnut. She is fastened with copper and treenails in the most approved manner. Her rig is that of a three-masted schooner; she has one smoke-pipe, one independent steam fire and bilge pump, two bilge injections, bottom valves to all openings in her bottom, and bunkers of wood. The *Falcon* is an excellent vessel for the service for which she was constructed.

The Steamer Thorn.—Hull built by Charles H. Mallory, Mystic, Conn. Machinery constructed by C. H. Delameter, New York. In Government service. Owners, Charles Mallory & Co.

Hull.—Length on deck, 125 ft. Breadth of beam, 26 ft. Depth of hold, 7 ft. Do. to spar-deck, 13 ft. 6 ins. Draft of water, 7 ft. Frames—molded, 11 ins.—sided, 7 ins.,—apart at centres, 26 ins. Tonnage, 225 tons.

Engines.—Vibrating lever. Diameter of cylinders, 20 ins. Length of stroke of piston, 18 ins.

Boilers.—One—tubular—located in hold, has a water bottom, and uses a blower to furnaces.

Propeller.—Diameter, 7 ft. 6 ins. Pitch, 12 ft. Blades 4. Material, cast iron.

Remarks.—This vessel is of white oak, chestnut, &c., and square fastened with copper and treenails. Her frames are filled in solid for half length; she has knees under her main deck, her rig is that of a schooner, and her water-ways are of pine. She has one independent steam fire and bilge pump, one bilge injection, and bottom valves or cocks to all openings in her bottom. The *Thorn* will give satisfaction wherever employed, as she is a vessel exceedingly well built.

The Steamer New England.—Hull built by John Englis, New York. Machinery constructed by Morgan Iron Works, New York. Route of service, Boston to St. Johns, N. B. Owners, John B. Coyle & Co.

Hull.—Length on deck, 230 ft. Breadth of beam, 32 ft. Depth of hold, 12 ft. 6 ins. Draft of water, 7 ft. 6 ins. Frames—molded, 14 ins.—sided, 7 ins.—apart at centres, 24 ins. Rig, foretopsail schooner. Tonnage, 896 tons.

Engines.—Vertical beam. Diameter of cylinder, 52 ins. Length of stroke of piston, 11 ft.

Boilers.—One—flue—located on deck. Uses blowers to furnaces.

Paddle Wheels.—Diameter, 27 ft. Number of blades, 27. Material, iron. Have sponsons one-half width.

Remarks.—This vessel is of white oak, &c., and fastened in the best manner. Her frames are not filled in solid, but they have iron straps, double and diagonally laid, 4 by $\frac{1}{2}$ inches, extending around them, and also a head strap of iron, 6 by $\frac{3}{4}$ inches, running around head of frame. She is coppered; has knees under her main deck, and is built in every respect in the most substantial manner. She is supplied with an independent steam fire and bilge pump; in fact, with all that will make a steamer of her class sea-worthy.

The Steamer Ta-Kaing.—Hull built by Roosevelt, Joyce & Co., New York. Machinery constructed by Dickson & Co., Scranton, Pa. Route of service, coast of China. Owners, Olyphant & Sons, New York.

Hull.—Length on deck, 154 ft. Breadth of beam, 28 ft. Depth of hold, 12 ft. 6 ins. Do. to spar-deck, 19 ft. 6 ins. Draft of water, 11 ft. Frames—molded, 14 ins.—sided, 5 ins.—apart at centres, 28 ins. Rig, brigantine. Tonnage, 505 tons.

Engines.—Vertical direct. Diameter of cylinders, 36 ins. Length of stroke of piston, 3 ft. 8 ins.

Boilers.—One—tubular—located in hold, and does not use blowers to her furnaces.

Propeller.—Diameter, 10 ft. 8 ins. Pitch, 19 ft. Material, cast iron.

Remarks.—This vessel is built of white oak, chestnut, &c., and fastened in the most approved manner. In her construction are combined strength, beauty of model, and speed. She has one independent steam fire and bilge pump, one bilge injection and bottom valves, or cocks, to all openings in her bottom. She is admirably arranged

for protection against fire, everything that experience has suggested, being resorted to in this respect. Her bunkers are of wood and iron. We bespeak a successful career for the *Ta-Kaing*.

The Steamer Blackstone.—Hull built by George Greenman & Co., Mystic, Conn. Machinery constructed by Corliss, Nightingale & Co., Providence, R. I. Route of service New York to New Orleans. Owners, J. & M. Smith & Co.

Hull.—Length on deck, 175 ft. 6 ins. Breadth of beam, 34 ft. 3 ins. Depth of hold, 12 ft. 3 ins. Do. to spar-deck, 18 ft. 3 ins. Draft of water, 12 ft. Frames—molded, 14 ins. sided, 10 to 12 ins.—apart at centres, 26 ins. Rig, Brig. Tonnage, 947 tons.

Engines.—Horizontal. Diameter of cylinder, 48 ins. Length of stroke of piston, 2 ft. 4 ins.

Boilers.—Four—tubular—located in hold, and use a blower to furnaces. These boilers are of a peculiar construction, from an original design of the builders of her machinery.

Propeller.—Diameter, 12 ft. 4 ins. Pitch, 16 ft. Blades, 4. Material, cast iron.

Remarks.—This steamer is of white oak, chestnut, &c., and square fastened with copper and treenails. She is strengthened in the most approved manner, and is an excellent sea-going vessel. Her frames are not filled in solid; she is fitted with knees under both main and spar decks; her water ways are of yellow pine, and she has four cargo ports.

The Steamer Fire Cracker.—Hull built by John Englis, New York. Machinery constructed by Neptune Iron Works, New York. Route of service, Tang-tsze river, China. Owners, H. W. Johnson & Co.

Hull.—Length on deck, 252 ft. Breadth of beam, 36 ft. Depth of hold, 12 ft. Draft of water at launching, 4 ft. 9½ ins. Do. with machinery, 6 ft. 6½ ins. Do. at load line, 8 ft. Area of immersed section at load draft, 5864 sq. ft. Weight of hull, 524 tons. Frames—molded, 14 ins.—sided, 6 ins.—apart at centres, 24 ins. Rig, topsail schooner. Tonnage, 1046 tons.

Engines.—Vertical beam. Diameter of cylinder, 60 ins. Length of stroke of piston, 12 ft.

Boilers.—Two—flue—located in hold; have water-bottoms, and one blower to each.

Paddle Wheels.—Diameter 30 ft. Material, iron. Have guards one half width and slatted.

Remarks.—This steamer is of white oak and chestnut, and is square fastened with copper and treenails. Around her frames are double and diagonally laid iron straps, 4½ by ⅝ inches, making them of great strength. The model of this vessel is very handsome, and her whole construction reflects great credit on her builder.

The Singapore (China) *Times* of August 23d, last, says:—"The American steamer *Fire Cracker*, Capt. H. W. Johnson, left New York at 4 P. M. on Saturday, June 7, arriving at St. Vincents on the 18th, at 4 A. M.; remained there till the 26th, when she left for Cape Town, arriving July 13th, remaining only half-an-hour, and leaving London papers of June 9, beating the mail to this point, eight days. Finding the harbor of Cape Town too rough to lie in, she ran around to Simon's bay, a distance of 57 miles, in 3 hours and 8 minutes. Was

detained there 9½ days for coal, on account of bad weather; left on the 23d, experienced very rough weather off the Cape, and arrived there August 1st, in 8½ days; remained there until the 5th, when she left for Singapore. The winds were so strong after leaving Mauritius, that she was obliged to run north five days before making a course for Singapore, where she arrived on the evening of the 20th inst. from Mauritius, a distance of 3920 miles. Her last three days run were 348, 332, and 329 miles. Running time from New York, 52½ days, being the quickest time ever made between the two ports of New York and Singapore."

The Steamer Anna J. Lyman.—Hull built by B. C. Terry, Keyport, N. J. Machinery constructed by Curtis & Schapter, New York. Route of service, New York Harbor. Owners, B. Coffin & Co.

Hull.—Length on deck, 126 ft. Breadth of beam, 23 ft. Depth of hold, 8 ft. 6 ins. Draft of water, 5 ft. 4 ins. Frames—molded, 10 ins.—sided, 6 ins.—apart at centres, 22 ins. Tonnage, 231 tons.

Engines.—Vertical beam. Diameter of cylinder, 34 ins. Length of stroke of piston, 7 ft.

Boilers.—One—flue—located in hold. Has no water bottom, and uses a blower to furnaces.

Paddle Wheels.—Diameter, 20 ft. Material, wood.

Remarks.—This is a well built, staunch steamboat, proving quite remunerative to her owners, in her present employment. She is of white oak, chestnut, &c., and is extremely well fastened with spikes, copper, treenails, &c. She has one smoke-pipe and her bunkers are of wood.

The Steamer Haze.—Hull built by Charles H. Mallory, Mystic, Conn. Machinery constructed by C. H. Delameter, New York. In Government service. Owners, Charles H. Mallory & Co.

Hull.—Length on deck, 132 ft. Breadth of beam, 25 ft. 2 ins. Depth of hold, 9 ft. 8 ins. Draft of water, 7 ft. 6 ins. Frames—molded, 11 ins.—sided, 6 ins.—apart at centres, 26 ins. Rig, schooner. Tonnage, 298 tons.

Engines.—Vibrating lever. Diameter of cylinder, 20 ins. Length of stroke of piston, 18 ins.

Boilers.—One—tubular—located in hold, has water bottom; does not use blowers.

Propeller.—Diameter, 8 ft. Pitch, 12 ft. Blades, 4. Material, cast iron.

Remarks.—This vessel is one of the best of her class. She is a superior craft in every respect. Her frames are of white oak, chestnut, &c., and square fastened with copper and treenails; they are filled in solid under engines and boiler. She has knees under both main and spar decks; her water ways are of white pine. She has one independent steam fire and bilge pump, one bilge injection and bottom valves or cocks to all openings in her bottom. A prettier and more sea-worthy steamer of her tonnage, is seldom seen than the *Haze*.

The Steamer Union.—Hull built by Charles H. Mallory, Mystic, Conn. Machinery constructed by C. H. Delameter, New York. In Government service. Owners, Hargous & Co., New York.

Hull.—Length on deck, 219 ft. 6 ins. Breadth of beam, 34 ft. Depth of hold 17 ft.

Do to spar deck, 24 ft. 6 ins. Draft of water, 16 ft. 3 ins. Frames—molded, 14 ins. —sided, 9 ins.—apart at centres, 27 ins. Rig—brigantine. Tonnage, 1253 tons.

Engines.—Vertical direct. Diameter of cylinders, 36 ins. Length of stroke of piston, 3 ft.

Boilers.—Two—return tubular—length, 19 ft. 6. ins. Shell, 12 ft. Have water bottoms. Do not use blowers.

Propeller.—Diameter, 13 ft. Pitch, 18 ft. Blades, 4. Material, cast iron.

Remarks.—This steamer is of white oak, chestnut, &c., and is square fastened with copper and treenails. Her frames are filled in solid for whole length, and they have iron straps, double and diagonally laid, $4\frac{1}{2}$ by $5\frac{1}{8}$ inches, running around them. She has knees under both main and spar decks, one bulkhead, and water ways of pine. The cabins of this vessel extend her entire length, and are capable of seating 200 persons. They are exquisitely finished with polished oak paneling. The sofas in the forward cabin are of oak and plush velvet. Bath rooms, toilets, &c., are circulated throughout the vessel. Upon the trial trip of this steamer, she made thirteen miles per hour with 23 pounds of steam, her propeller making 66 revolutions per minute; it must be understood that her boilers were very "oily," and her coal, unfortunately, bad. The *Union* was built for the especial purpose of being put upon the route between New York and Havana, but being, in every respect, such an excellent steamer, she was taken by the Government for their use.

The Steamer Convoy.—Hull built by Thomas Stack, Williamsburgh, L. I. Machinery constructed by Fulton Iron Works, New York. In Government Service. Owners, Arthur Leary & Co., New York.

Hull.—Length on deck, 180 ft. Breadth of beam, 26 ft. 3 ins. Depth of hold, 9 ft. 2 ins. Draft of water, 5 ft. Frames—molded, 12 ins.—sided, 6 ins.—apart at centres, 26 ins. Tonnage, 377 tons.

Engines.—Vertical beam. Diameter of cylinder, 40 ins. Length of stroke of piston, 10 ft.

Boilers.—One—tubular—located in hold; does not use blowers; has water bottom.

Paddle Wheels.—Diameter, 25 ft. 6 ins. Material, iron.

Remarks.—This vessel is of white oak, &c., and well fastened with copper, &c. Around her frames iron straps extend, giving them great strength. She is supplied with one independent steam fire and bilge pump, and all necessary injections, valves, &c. The period this vessel has been in service, though limited, has given her owners ample opportunity to note her sea-worthiness, her excellent carrying capacity, and the successful working of her machinery.

The Steamer Eagle.—Hull built by J. Westervelt & Co. Machinery constructed by Allaire Works, New York. Route of service, New York to Havana. Owners, Spafford, Tillston & Co, New York.

Hull.—Length on deck, 237 ft. 6 ins. Breadth of beam, 37 ft. Depth of hold, 14 ft. 6 ins. Do. to spar deck, 21 ft. 6 ins. Draft of water, 13 ft. Frames—molded, 15 ins. —sided, 13 ins.—apart at centres. 30 ins. Rig, Brig. Tonnage, 1570 tons.

Engines.—Vertical beam. Diameter of cylinder, 75 ins. Length of stroke of piston, 12 ft.

Boilers.—Two—flue—located in hold; does not use blowers; have water bottoms.
Paddle Wheels.—Diameter, 30 ft. Material, iron.

Remarks.—This steamer is built of white oak, chestnut, &c., and square fastened with copper and treenails. Around her frames extend iron straps, double and diagonally laid, 4 by $\frac{3}{8}$ inches, thus rendering them staunch and of great strength. She has knees under her main and spar decks, water ways of pine, and bunkers of wood and iron. She is fitted with one independent steam fire and bilge pump of large size, bilge injections, and bottom valves to all openings in bottom. Upon the route of her service, the *Eagle* has given great satisfaction, carrying large numbers of passengers, and heavy cargoes of freight. This is not at all astonishing, as she is an excellent and comfortable vessel in every respect.

The Steamer Thames.—Hull built by George Greenman & Co., Mystic, Conn. Machinery constructed by C. H. Delameter, New York. Route of service, New York to New London. Owners, George Greeneman & Co.

Hull.—Length on deck, 145 ft. Breadth of beam, 30 ft. Depth of hold, 9 ft. Do. to spar deck, 16 ft. Frames—molded, 12 ins.—sided, 10 ins.—apart at centres, 24 ins. Draft of water, 9 ft. Rig, three-masted schooner. Tonnage 362 tons.
Engines.—Vertical direct. Diameter of cylinder, 34 ins. Length of stroke of piston, 2 ft. 6 ins.
Boilers.—One—tubular—located in hold; uses a blower to furnaces. Has water bottom.
Propeller.—Diameter, 10 ft. Pitch, 16 ft. Blades, 4. Material, cast iron.

Remarks—This vessel is of white oak, &c., and square fastened with the usual materials in the best manner. She has knees under main and spar decks, and her frames are filled in solid under engine. She has an independent steam fire and bilge pump, one bilge injection, and bottom valves to all openings in her bottom. Her spar deck is enclosed, and she is fitted with an independent rudder post.

The Steamer Touitia.—Hull built by Thos. Collyer, New York. Machinery constructed by Neptune Iron Works, New York. Route of service, Coast of China. Owners, McCredy, Mott & Co., New York.

Hull.—Length on deck, 149 ft 6 ins. Breadth of beam, 26 ft. 7 ins. Depth of hold, 10 ft. 2 ins. Draft of water, 8 ft. 6 ins. Frames—molded, 11 ins.—sided, 11 ins.—apart at centres 22 ins. Rig, foretopsail schooner. Tonnage, 496 tons.
Engines.—Vertical direct. Diameter of cylinder, 26 ins. Length of stroke of piston, 2 ft. 2 ins.
Boilers.—One—flue—located in hold; does not use blowers. Has water bottom.
Propeller.—Diameter, 9 ft. Pitch, 15 ft. Blades, 4. Material, cast iron.

Remarks.—This vessel is of white oak, chestnut, &c., and square fastened with copper and treenails. Her frames are not filled in solid, but around them extends iron straps, double and diagonally laid, $2\frac{1}{2}$ by $\frac{5}{8}$ ins., giving them strength. She has knees under her deck, water ways of white pine, one smoke pipe, one independent steam fire and bilge pump, one bilge injection, bunkers of wood, and bottom

valves or cocks to all openings in her bottom. The *Touitia* has beauty of model, and all else to make her a successful steamer. The vessels from the hands of Mr. Collyer have always sustained a reputation that was ever flattering to him, and an honor to American Naval Architecture.

The Steamer Seagull.—Hull built by Maxson, Fish & Co., Mystic, Conn. Machinery constructed by C. H. Delameter, New York. Route of service, New York to Providence, R. I. Owners, Commercial Steamboat Co.

Hull.—Length on deck, 165 ft. Breadth of beam, 33 ft. 8 ins. Depth of hold, 10 ft. Do. to spar deck, 17 ft. 6 ins. Draft of water, 12 ft. Frames—molded, 13 ins.—sided, 10 ins.—apart at centres, 26 ins. Rig, three-masted schooner. Tonnage, 500 tons.

Engines.—Vertical direct. Diameter of cylinder, 36 ins. Length of stroke of piston, 3 ft.

Boilers.—One—tubular—located on deck; does not use blowers.

Propeller.—Diameter, 12 ft. Pitch, 18 ft. Blades, 4. Material, cast iron.

Remarks.—This vessel is of white oak and chestnut, and fastened with copper and bolts. Her frames are filled in solid under engine and thirty feet forward. The outside planking is 4 inches thick; from the floor heads to lower deck, it is sealed with white oak 5 inches thick, and 4 inches from lower deck to main rail on plankshear. The vessel is supplied with one independent steam fire and bilge pump, and fitted with bilge injections and bottom valves to all openings in her bottom. Her bunkers are of wood. Great precaution has been observed in her construction to avoid fire, her security and provisions in this respect being excellent. Her owners are sanguine that she will prove a vessel worthy of the patronage of the traveling public.

The Steamer Henry Burden.—Hull built by Webb & Bell, Greenpoint, L. I. Machinery constructed by Henry Esler & Co., Brooklyn, L. I. In government service. Owners, P. A. Burden & Co.

Hull.—Length on deck, 138 ft. 6 ins. Breadth of beam, 24 ft. Depth of hold, 9 ft. Draft of water, 3 ft. 6 ins. Frames—molded, 10 ins.—sided, 6 ins.—apart at centres, 24 ins. Tonnage, 280 tons.

Engines.—Vertical beam. Diameter of cylinder, 32 ins. Length of stroke of piston, 3 ft.

Boilers.—One—flue—located in hold; does not use blowers. Has no water bottom.

Paddle Wheels.—Diameter 28 ft. Material, wood.

Remarks.—This vessel is of white oak, &c., and well fastened. She is supplied with one independent steam fire and bilge pump, and one bilge injection. She was designed and built for service in and around the harbor of New York, but the Government finding her well adapted for service at Fortress Monroe, and along the coast in that vicinity, took possession of her, and are now using her as a transport.

The Steamer Matteawan.—Hull built by B. C. Terry, Keyport, N. J. Machinery constructed by Fletcher, Harrison & Co., New York. Route of service, New York to Keyport. Owners, Keyport and Monmouth Steamboat Co.

Hull.—Length on deck, 210 ft. Breadth of beam, 28 ft. Depth of hold, 8 ft. 8 ins., Draft of water, 4 ft. 6 ins. Frames—molded, 16 ins.—sided, 7 ins.—apart at centres, 24 ins. Tonnage, 495 tons.

Engines.—Vertical beam. Diameter of cylinder, 42 ins. Length of stroke of piston, 12 ft.

Boilers.—One—flue—located in hold; uses a blower to furnaces. Has no water bottom.

Paddle Wheels.—Diameter, 28 ft. Material, iron and wood.

Remarks.—This steamer is built of white oak, &c., and well fastened. She has one independent steam fire and bilge pump, and one bilge injection. Her bunkers are of wood; she has a saloon upon her promenade deck and two smoke-pipes. The *Matteawan* is an excellent vessel of her class, and has given much satisfaction upon the route of her service. She is comfortable, finely fitted up, and of greater speed than is usual to anticipate of a steamer of her character. B.

New York, April 15, 1863.

(To be Continued.)

Translated for the Journal of the Franklin Institute.

Theory of Steel.

M. H. Caron in a communication made to the French Academy of Sciences attributes the combination of iron with carbon or other elements of the same family by which tempered steel is formed, to the sudden shrinking of the mass, which he considers as analogous to the instantaneous compression produced by hammering. In illustration of this point he found that by hammering a bar of iron heated to a bright redness, on an anvil covered with powdered charcoal, the face of the bar in contact with the charcoal, was, in spots, converted into steel, and capable of resisting the file. His researches also confirm the results of previous experiments, that the density of steel is decreased by tempering. In one specimen, after thirty successive temperings, the density was reduced from 7·817 to 7·743.

Cloths Rendered Uninflammable by Sulphurous Vapor.

From the Practical Mechanic's Journal, April, 1863.

M. Sauvageon, a French investigator, has discovered that cotton cloth which has been exposed for a certain time to the vapor of burning sulphur, assumes such an amount of incombustibility that, although it will char and become brittle when held over the flame of a spirit lamp, it cannot be made to take fire, while under like conditions similar cloth, but unprepared in this way, inflamed immediately. If the alleged facts be borne out in practice, the problem is solved, for the simplest domestic means may be devised for subjecting, after being washed, all white clothing to the vapor of sulphur, which will tend to make it still whiter. Moreover, it may not prove necessary to repeat the exposure so often.

The New Gun Metal.

From the London Chemical News, No. 167.

A letter in the *Times* from one of our most distinguished metallurgists, signed with the well known "Y," gives some interesting particulars respecting the new gun metal lately invented in Austria by Baron von Rosthorn. Before giving any account of this new alloy, the writer states his opinion that the days of wrought iron are numbered, and that its place will be soon supplied by steel in some form or other. The new alloy, which has received the name of "sterrometal," from a Greek word signifying tough or firm, is composed of copper, spelter, iron, and tin, in proportions that may be slightly varied without much affecting the result. In color it resembles brass rather than gun metal; it is very close in its grain, and free from porosity. It is possessed of considerable hardness, and will take a very fine polish. Several eminent Vienna engineers have tried it for the cylinders of hydraulic presses with great success. Two specimens of the alloy have been submitted to rigorous tests by the Polytechnic Institute of Vienna and the Imperial Arsenal. The proportions used in each case were the following:—

	Polytechnic Institution.	Imperial Arsenal.
Copper,	55·04	57·63
Spelter,	42·36	40·22
Iron,	1·77	1·86
Tin,	0·83	0·15
	100·00	99·86

The specimen tested at the Polytechnic Institute gave the following results per sectional inch (English):—A bar prepared by simple fusion, bore a weight of twenty-seven tons. Forged red hot it broke at thirty-four tons. Drawn cold, at thirty-eight tons; the figures in the case of the specimen tried at the Imperial Arsenal being twenty-eight, thirty-two, and thirty-seven tons respectively; while the best English gun metal, containing ten per cent. of tin and ninety per cent. of copper, broke at eighteen tons under similar circumstances. The specific gravity of the metal is about 8·37 when forged hot. These results, which are official, are truly astounding when we consider that the average breaking strain of wrought iron, as given by Mr. Anderson, of Woolwich Arsenal, is only twenty-six tons, whilst that of the best steel is only thirty-five tons per sectional inch. The elasticity of the sterrometal is also very great. It may be stretched $\frac{1}{60}$th of its length without undergoing permanent elongation; gun metal giving only $\frac{1}{150}$th, and wrought iron $\frac{1}{1500}$th. No surprise is, therefore, felt when we are told that a tube of sterrometal is capable of resisting a pressure of 763 atmospheres, a tube of wrought iron of similar size and form giving way under 267 atmospheres.

Quoting Mr. Anderson, the writer concludes by saying that the best alloy for guns is yet to be discovered. It seems to us, however, that sterrometal is very near perfection. The subject of alloys is one that, with constant and persevering experiment, must yield most valuable

results, and we strongly advise any young chemist desirous of laurels and fortune to take up the matter. It seems singular that, with all our boasted knowledge of chemistry and metallurgy, there are but half-a-dozen alloys that may be turned to economic uses.

Gas Purification by Oxide of Iron. By GEORGE ANDERSON.

From the Gas Light Journal, No. 271.

SIR:—As the question of gas purification by oxide of iron is likely to be introduced to your pages again, through the proceedings now instituted to obtain a prolongation of the patent, it may be interesting to your readers to have the following facts placed before them.

Being compelled to abate the lime nuisance at the Dover Works some three years ago, we provided ourselves with a quantity of oxide of iron, purchased from the patentee, Mr. Hills, which we worked until it became thoroughly saturated with sulphur, and no longer capable of revivifying in the open air, as is usually adopted. Desiring to know whether I could recover it by expelling the sulphur it contained, by heat, I charged retorts with it, until I had obtained sufficient to fill a purifier, added sawdust to it, and began the use of it again. I found its purifying powers restored. Also that it revivified on exposure to the air as before, and that it could be used over and over again.

I then erected a kiln for the purpose of restoring the whole of my stock, and the process has been continued for about eighteen months with perfect success.

In this process, the material is kept at a dull red heat for ten or twelve hours, and has become, I would say, anhydrous.

I think some of the evidence, on former trials, was to the effect that oxide of iron once made anhydrous, was useless in the purification of gas. This statement is at variance with the facts above stated.

16, Adam Street, Strand, March 5, 1863.

Magneto-Electric Lighthouse. By F. H. HOLMES.

From the London Athenæum, Jan., 1863.

May I ask your permission to offer a few observations on the notice of the magneto-electric light which appeared in the *Athenæum* of the 29th of November last? The details therein given were correct *at the dates referred to*, and the well-wishers of the light cannot but welcome so clear and concise an account of the application of the invention to lighthouses; but the time which has elapsed since has been occupied in perfecting the efficiency of the light, and it is hoped that you will allow the result to be recorded.

The improvement has arisen from using a different lamp. That instrument is no longer a delicate piece of complicated clock-work, but so simple an affair that the movement of the carbons is entirely accomplished with one wheel and one pinion; and the lamps which have been in use at Dungeness for nearly seven months, and for some time

before that on my own premises, have never been even opened to be oiled. When to this is added the fact that the light, if arbitrarily extinguished, will now instantly re-light itself, a certainty of action has been arrived at which leaves little to be desired. The liability to sudden and spontaneous extinction has also disappeared. The light was burnt every day in the International Exhibition from half-past one o'clock to five without once going out: and there is reason to believe that at Dungeness a steadiness and continuity practically complete has been obtained.

The only element of interruption that remains arises from certain impurities, silica or metallic residuum, in the carbons; and when they have decomposed to a point where iron or antimony occurs, there is a slight change of color, an absolutely momentary flicker (not an extinction), which, though it would cease to exist if carbons could be obtained quite pure, is practically of no consequence whatever.

This improvement in the lamp has of course altered the relative simplicity of the two systems of oil and electricity enormously. There is really nothing now to look after in the latter that the customary attendant on a steam-engine could not learn efficiently in a few hours; and the chance of break-down to that which has now become ordinary mechanism is no greater than exists every day, without (as a rule) occurring, in every engine-room in the kingdom, and is, of course, less than a sea-going steam-vessel risks with impunity for months together. If, in addition to this, it is considered that oil, although in a sense simple, is liable to an adulteration very difficult to detect; and that in proportion to adulteration is the necessity for frequent trimming; and that, with the best oil known, every four-wicked lamp *must* be trimmed at least once every night, during which time,—from five to fifteen minutes,—the only light in the lantern proceeds from the hand-lamps of the keepers, it follows that the Magneto-Electric Light is preferable to the oil lamp on account, amongst other things, of its unbroken continuity. The question of expense, even if that were very much greater than it is, is one that could hardly affect its use in a country which, from its wealth of life and merchandise afloat, has such need to employ the best light that can be had; but, although where the large and very costly apparatus and lantern for the oil system have been already procured, there would be no set-off to the cost of the small engine and the magneto-electric machine itself, yet at a new station, where the whole thing had to be done from the beginning, the saving in the difference of size of lantern and of apparatus, and the easiness with which the machinery could be placed in the light-house tower immediately under the lantern, so that no more than the customary two men would be necessary, would reduce the excess of outlay to a minimum: the proportions being for the magneto-electric light,—first cost, about one-sixth more, and for the maintenance about half as much again. When there were two lights adjacent, a portion of the machinery necessary for one could be applied to both, and the working expenses would then be, for the two lights, in the proportion of 1·142 magnetic to 1·000 oil, or thereabouts.

The great questions involved are quality, intensity, and efficiency of light. Regarded from this point, the magneto-electric is very much the cheaper; that is to say, it gives a great deal more for the money. Moreover, the intensity and penetrative power of the light can be increased indefinitely, at a very small ratio of increased cost.

If space could be afforded to me, I should have no difficulty in showing, by considerations of pure science, that from the very nature of light itself, the magneto-electric light *must* be enormously greater in penetrative power than the flame of the oil lamp; but it is sufficient for the present to express my thanks that through the medium of your pages the attention of the general public has been directed to the facts by which this is being practically proved.

Northfleet, Jan. 1, 1863.

On the Results of some Experiments on the Mechanical Properties of Projectiles. Read by Dr. Fairbairn, the President of the Section.

From the London Practical Mechanic's Journal, Feb., 1863.

He commenced by stating that, in the investigations which had taken place with regard to projectiles and armor-plated ships, one great difficulty that had arisen was to get good plates of sufficient thickness, and vessels of sufficient tonnage to carry those plates. It appeared that they were limited to plates of five inches in thickness; with plates heavier than that, a ship would not be what was technically called "lively." He had attended the experiments at Shoeburyness from the commencement, and they had reference to the force of impact. He would state the results of the more recent experiments, which had not yet been published. The first series of experiments had reference to the quality of the plates and the properties of the iron best calculated to resist impact. There were three qualities required: first, that the iron should not be crystalline; but secondly, that it should be of great tenacity and ductility; and thirdly, that it should be very fibrous. The mean statical resistance to crushing of the two flat-ended specimens of cast-iron is 55·32 tons per square inch. The mean resistance of the two round-ended specimens is 26·87 tons per square inch. The ratio of resistance, therefore, of short columns of cast iron with two flat ends to that of columns with one flat and one round end is as 56·32 to 26·87, or as 2·05 to 1,—an extremely close confirmation of Prof. Hodgkinson's law. Applying this same rule to the steel specimens, it would appear that the flat-ended shot should have sustained a pressure of 180 tons per square inch before fracture. In the experiment it actually sustained 120 tons per square inch without injury, excepting a small permanent set. In the experiments with cast iron, the mean compression per unit of length of the flat-ended specimens was ·0665, and of the round-ended ·1305. The ratio of the compression of the round-ended to the flat-ended shot was, therefore, as 1·96 : 1, or nearly in the inversed ratio of the statical crushing pressures. Applying this law to the case of the steel flat-ended specimen, it may be concluded that the compression before fracture would have been only ·058 per unit of length. The determination of the statical crushing pressure of

the flat-ended steel shot is 180 tons per square inch and its compression as ·058 is important, on account of the extensive employment of shot of this material, size, and form in the experiments at Shoeburyness. In the case of the lead specimens, the compression with equal weights was the same whether the specimen were at first round-ended or flat-ended. This is accounted for by the extreme ductility of the metal and the great amount of compression sustained. In regard to the wrought iron specimens, it may be observed that no definite result is arrived at, except the enormous statical pressure they sustain, equivalent to 78 tons per square inch of sectional area, and the large permanent set they then exhibit:—

	Statical Resistance in tons per square inch	Dynamical Resistance in foot lb. per square inch.
Cast iron, flat-ended, .	55·32	776·8
Cast iron, round-ended, . .	26·87	821·9
Steel, round-ended, . .	90·46	2515·0

In the experiments on the wrought iron specimens, the flat-ended steel specimens, and the lead specimens, no definite termination was arrived at, the material being more or less compressed without any fracture ensuing. The mean resistance of the specimens of cast iron is 800 foot-pounds per square inch; that of the specimen of steel is 2515, or rather more than three times as much. The conditions which would appear to be desirable in projectiles, in order that the greatest amount of work may be expended on the armor-plate, are—1. Very high statical resistance to rupture by compression. In this respect, wrought iron and steel are both superior to cast iron; in fact, the statical resistance of steel is more than three times, and that of wrought iron more than two-and-a-half times that of cast iron. Lead is inferior to all the other materials experimented on. 2. Resistance to change of form under great pressures. In this respect, hardened steel is superior to wrought iron. Cast iron is inferior to both. The shot which would effect the greatest damage to a plate would be one of adamant, incapable of change of form. Such a shot would yield up the whole of its *vis viva* to the plate struck; and, so far as experiment yet proves, those projectiles which approach nearest to this condition are the most effective. The President stated that steel shots might be made at a comparatively small cost. M. Bessemer had told him, that if he had a large order he could produce steel shots at a little more than the price of iron; but if the ingots as cast had to be rolled or hammered to give them fibre, they would cost near £30 a ton, instead of £8 or £10 per ton.

Mr. J. Nasmyth inquired whether chilled cast iron flat-headed shot had been tried? The process of chilling cast iron was very simple and inexpensive. If chilled flat-ended cast iron shot had not been tried, it was very desirable it should be—Dr. Fairbairn said they had not been tried; but he believed that shot thus made being hardened to a certain

depth, the velocity being the same, would, in striking the object, break as if it had not been hardened at all. However, he would have experiments made; and he hoped that before the next meeting of the Association the matter would be proved experimentally.

Proc. British Association, Oct. 6, 1862.

Iron Vessels in the French Navy.

From the London Mechanics' Magazine, January, 1863.

Mr. Donald McKay, in his report on the French navy, says the reason why iron war vessels are somewhat at a discount in France, is the insuperable difficulty of preventing their fouling. We have now another signal example of the same difficulty amongst ourselves:—

The *Urgent*, iron screw troopship, lately paid out of commission at Portsmouth, on her return from service in China, has been placed in dock at Portsmouth, and her bottom found to be covered with barnacles and other marine adhesions. The *Urgent* had been previously, during the term of her commission, carefully coated over her bottom with various so-called patent preservative compositions. The result has only been to coat her bottom with shell matter and weeds more plentifully than could possibly have been the case without them. We have before had occasion to remark on the apparent uselessness of these anti-fouling preparations, as illustrated by vessels docked at Portsmouth.

On the Manufacture of Nickel. By Lewis Thompson, M.R.C.S.,&c.

From Newton's London Journal, February, 1863.

Commercial nickel is a very impure article, and bears no more relation to pure nickel than brass or bell-metal does to copper. The following table will show its average composition, as it is found in the market:—

	English.	English.	German.	German.	French.
Nickel,	86·0	84·5	75·7	80 9	77·5
Cobalt,	6·5	8·2	2 2	5·2	3 7
Copper,	—	0·6	12·5	7·7	10·2
Iron,	1·4	1·1	0·4	1 2	1·1
Arsenic,	1·3	0·4	2·6	3 8	2 8
Zinc,	2 0	0·7	4·1	0 5	1·4
Manganese,	0·2	0·8	—	—	0·6
Sulphur,	1·7	2 2	2·3	0·2	1·1
Carbon,	0 5	0 9	0 2	0·1	0 7
Silica and Alumina,	0·4	0·6	—	0·4	0 9

From what I have before said, there is every reason to suppose that our accounts of metallic nickel relate to an alloy of that metal with cobalt, in greater or smaller proportion; that, in fact, absolutely pure nickel has not hitherto been obtained. Pure nickel is, however, much more easily made than pure cobalt, for its affinity for oxygen is much less. Taking advantage of this fact, I made up a quantity of pure

oxide of nickel into a paste by means of a little water, and forced this paste through a perforated earthenware plate, so as to form it into a granulated mass; when this mass had been thoroughly dried, I introduced it into a porcelain tube, and after heating it red hot, I passed a current of pure hydrogen gas over it, and continued this until it had become cold. The gray metallic sponge thus produced was fused with a little borax in a crucible, lined with pure alumina, and yielded a beautiful white silvery looking button of the weight of 620 grains; its specific gravity was 8·575, and it was almost as soft as copper. Its malleability seemed very great indeed, for a piece of it was rolled out nearly to the thinness of tin foil; it showed, however, a disposition to tarnish after a few days' exposure to the air, and became then of a pale yellow color—a kind of green-sickness tinge. Its magnetic properties were less decided than those of either cobalt or iron; and judging by the globular form and other evidences of perfect fusion in the button, I believe that nickel is much more fusible than the two metals just mentioned. When portions of it were melted with copper and zinc, in the quantities usually adopted to form albata, it produced a compound vastly superior in appearance to any of the miserable makeshifts that now disgrace our markets. Indeed, I am quite convinced that it would well repay any respectable person to commence the manufacture of pure nickel; and it would not surprise me, if a compound of aluminium and nickel could be formed, which, for beauty of appearance, might equal silver, and surpass it in durability and freedom from sulphurous deterioration.

Whilst alluding to the advantages of an improvement in the manufacture of nickel, it may not be amiss for me to notice two points of some importance in the way of improvement. At present the extraction of nickel from the ore is made to depend very much upon the affinity of arsenic for that metal, so as to form with it an arseniuret of easy fusibility and sufficient specific gravity to separate freely from the melted slag or gangue; and for this purpose large quantities of arsenic are employed by the workmen, not only to the detriment of their own health, but also to the injury of their neighbors. This pernicious practice is quite unnecessary, as I have myself proved by experiments upon a large scale; for example, after carefully roasting six hundred weight of the common ore of nickel, which is an arsenio-sulphuret, I mixed it with half its weight of chalk, and threw the mixture into a cupilo furnace in full blast; the result was, that the lime of the chalk formed, with the quartz and oxide of iron in the ore, a perfect flux, whilst the oxide of nickel, being easily reduced to the metallic state, fell, in that condition, into the well of the cupilo, from whence it was run out in a melted form, and readily separated from the slag. There was no appreciable loss of nickel in this operation, and the rough metal was found to contain 88 per cent. of pure nickel, the rest being cobalt and iron, with a little sulphur, but no arsenic could be detected in it; moreover, this rough metal might, from the cheapness of the process, have been profitably sold at 3*s.* per lb., and was decidedly more pure than the ordinary commercial nickel.

The other point to which I have alluded is applicable to the wet mode of separating nickel, and depends upon a fact hitherto, I believe, unnoticed by chemists. If we have in solution a mixture of the sulphates of nickel, cobalt, zinc, manganese, iron, and copper, we have only to add to this solution in a warm state, as much sulphate of ammonia as it will disolve, and then set it aside to cool. Almost every particle of the nickel and cobalt will separate as a green crystallized powder, and leave the other metals in solution. The explanation is very simple. The sulphates of nickel and cobalt form triple salts or alums with the sulphate of ammonia, and these salts are absolutely insoluble in a cold saturated solution of sulphate of ammonia, particularly when this solution is slightly acidulous. I shall conclude these remarks upon nickel by stating that this metal appears to possess the property of "welding" like iron. At my request, a workman heated two small bars of nickel, which had been previously powdered over with borax, the bars were heated in a forge, and the two hot ends "jumped" together, that is to say, the white hot ends were forcibly driven one against the other by gentle blows with a hammer, applied to the other ends, the symmetry of the bar being preserved by blows applied laterally. Although the point of junction was afterwards subjected to much twisting, straining, and so forth, with a view to test its cohesive power, yet it showed no signs of weakness, even after much cold hammering.

Uninflammable Stuffs.

From the Lond. Mechanics' Magazine, March, 1863.

On this important subject the French Academy of Sciences has received a report from MM. Payen, Velpeau, and Rayer, in which M. A. Chevalier's paper, sent in to the Academy on the 25th of January last, is discussed. From this report it appears that only three salts have hitherto been found that may be successfully applied to the purpose in question, viz: that of preventing ladies' dresses from catching fire. There are many other salts that would do the same, but not without spoiling the dye, or the gloss, or the texture of the stuff, &c. Of the three in question, the sulphate and phosphate of ammonia have the inconvenience of being decomposed by the heat of a smoothing-iron; but they are applicable in those manufactures where stuffs are stiffened by the action of hot air or cylinders heated by steam. They exercise no action upon either the thread or the color of the stuff. The phosphate of ammonia may be mixed with half its weight of hydrochlorate of ammonia. To obtain an efficacious solution, 20 per cent. of this mixture must be dissolved in water. A solution of 7 per cent. of sulphate of ammonia produces the same effect, and is therefore the most economical salt that the trade can employ. But in those cases in which the smoothing-iron cannot be dispensed with, as in linen, for instance, a solution of 20 per cent. of tungstate of soda should be preferred. To obtain the desired effect, all these solutions must be applied to the stuffs after they have been stiffened and dried, because starch is always used in a weaker solution than that required

for these salts. Acid tungstates destroy the thread of cotton stuffs, like borax, alum, and other substances previously recommended. The tungstate of soda is prepared in Cornwall, where the tin mines yield a large quantity of wolfram. It costs from £ 12 to £ 18 per ton, or about 4f. per kilogramme. The sulphate of ammonia costs about £ 14 per ton; it is produced in gasworks, and has hitherto been used for manure.—*Galignani.*

PROCEEDINGS OF THE BRITISH ASSOCIATION.

From the London Athenæum, Oct., 1862.

Section G.—Mechanical Science.

Mr. W. Smith read the Report of the Committee appointed at the last meeting of the Association to inquire into the causes of Railway Accidents. This Report was simply provisional, pointing out the steps now in progress for collecting information.

Messrs. Williamson of Liverpool, made a communication relative to the merits of Wooden and Iron Ships, with regard to cost of repairs and security for life, and in the event of accidents at sea; calling attention in particular, to an iron ship of their own, the *Santiago*, which met with a collision, the consequences of which would have been absolute destruction of the vessel had she been of wood; whereas, being of iron and having water-tight compartments, the vessel was able to pursue her voyage, and was repaired at the cost of a few hundred pounds, instead of several thousands, which would have been necessary had she been made of wood, and could have been preserved from foundering.

Prof. W. J. M. Rankine read a paper "On the Form and Motion of Waves at and near the Surface of Deep Waters."—This paper was a summary of the nature and results of a mathematical investigation, the details of which have been communicated to the Royal Society. The investigations of the Astronomer-Royal and of Mr. Stokes on the question of straight-crested parallel waves in a liquid, are based on the supposition that the displacements of the particles are small compared with the length of a wave. They proceed by a method of approximation, which Mr. Stokes has carried furthest. Hence it has been very generally inferred that the results of those investigations when applied to waves in which the displacements are considerable, as compared with the length of wave, are only approximate. In the present paper, the author proves that one of those results,—viz: in very deep water the particles move with a uniform angular velocity in vertical circles, where radii diminish in geometrical progression with increased depth, and consequently, that surfaces of equal pressure, including the upper surface, are trochoidal,—is exact for all possible displacements, how great soever. The author proves further, that the centres of the orbits of the particles in a given surface of equal pressure stand at a higher level than the same particles do when the liquid is still, by a height which is equal to the height due to the velocity of revolution of the particles; and that, consequently, the mechanical energy of a wave is half actual and half potential (half being due to motion and half

to elevation), and the destructive power of a wave is double of that due to the motion of its particles alone. The hydrostatic pressure at each individual particle during the wave motion is the same as if the liquid were still. In an Appendix to the paper is given the investigation of the problem, to find approximately the amount of the pressure required to overcome the friction between a trochoidal wave-surface and a wave-shaped solid in contact with it. The application of the result of this investigation to the resistance of ships was explained in a paper read to the British Association in 1861, and published in various engineering journals in October of that year.

A paper was brought before the Section by Mr. C. Vignoles, "On the Practice and Principles of Diverting Rivers, and the Stoppage of Breaches in Embankments."—The author proceeded to describe a method successfully adopted by him in dealing with the River Ebro. The plan he pursued was one very generally adopted at the present day by the Dutch engineers,—namely, gradually shallowing the river throughout at the required spot by means of fascine work. It consists in forming large rafts of fascines, and floating them down to the desired place; loading them evenly with stones, and thus sinking them down to the bottom; and repeating the operation till they rise above the surface of the water. This, he contended, was a more judicious plan than that of piling from the sides to the centre, the result of which was the continual narrowing of the water way, which caused the tide or stream to rush through with such accelerated violence so as frequently to destroy the works before they were completed; whilst, by the use of fascines, the water was gradually shallowed all over and its force checked by degrees. The Dutch engineers had long since given up the piling system for such purposes.

A paper by Mr. J. Sewell, was read, "On the Prevention of Railway Accidents."—The author considered that the main cause of accidents was the want of punctuality in the trains; and that this arose mainly from the overloading of them, which rendered it impossible that they could keep time. Engines were made to perform certain work and draw certain loads, and if these were exceeded it was impossible that time could be kept. This was a matter that the public could not ascertain for themselves, and he, therefore, advocated the importance of having engines licensed like boats, omnibuses, &c., by Government to draw certain loads; and a statement giving that information should be placed conspicuously on the engine. This would prevent the overloading, as it would be in the power of every passenger to see whether the power of the engine was duly apportioned to the carriages it had to draw.

A discussion took place, in which it was objected that such a proceeding would be impracticable, looking at the variety of work which an engine had to perform, by reason of varying inclines, the state of the weather, and the uncertainty as to the weight of carriages and the varying number of passengers.

"On an Improved Painting Telegraph Apparatus," by Mr. T. Sortain.

"On the Manufacture of Armor Plates," by Mr. A. C. Tylor.

"On Instruments for observing the Motion of Vessels at Sea, with reference to Sea-sickness," by Mr. J. W. Osborne.

FRANKLIN INSTITUTE.

Proceedings of the Stated Monthly Meeting, April 16, 1863.

John Agnew, Vice President, in the Chair.

Isaac B. Garrigues, Recording Secretary.

The minutes of the last meeting were read and approved.

Donations to the Library were received from the Royal Astronomical Society, the Royal Geographical Society, and the Statistical Society, London; the Canadian Institute, Toronto, and Major L. A. Huguet-Latour, Montreal, Canada; Frederick Emmerick, Esq., Washington City, D. C.; E. W. Hilgard, Jackson, Mississippi; J. Spencer Turner, Chicago, Illinois; Young Men's Mercantile Library Association, Cincinnati, Ohio; Frank H. Stover, Cambridge, Mass.; Young Men's Association, Buffalo, and Dr. Warren Rowell, City of New York; Hon. A. H. Glatz, Senate of Pennsylvania, and T. C. Zulich, Esq., Harrisburg, Pennsylvania; Messrs. John Pennington & Son, Geo. M. Conarroe, Esq., H. P. M. Berkinbine, Esq., the Girard College for Orphans, and Prof. John F. Frazer, Philadelphia.

The Periodicals received in exchange for the Journal of the Institute were laid on the table.

The Treasurer's statement of the receipts and payments for the month of March was read.

The Board of Managers and Standing Committees reported their minutes.

Candidates for membership in the Institute (3) were proposed, and the candidates (5) proposed at the last meeting were duly elected.

Mr. Washington Jones exhibited an improved Stop Valve, the invention of H. G. Ludlow of New York. The valve, in this instance, slides vertically across the opening, and when down, is kept in close contact with the seat by a wedge which is loosely secured to the back of the valve. The motion of the spindle in closing the valve forces down the wedge, and presses the face of the valve firmly against the seat.

Mr. Thomas Shaw exhibited a glass tube which he fractured by introducing into the same a few grains of sand. Mr. S. stated that the tube was like those usually employed for steam gauges and capable of bearing an internal pressure of over 1000 pounds, but that rubbing a few grains of sand or emery against the inside surface, was certain to cause the fracture, although it did not always follow immediately, he having known the tube to lay two weeks before breaking. Mr. Shaw in explanation of the cause of this, stated, that he attributed it to the manner of making the tubes, and that when they were cooled and straightened, by rolling them upon a flat surface, before they were hardened, it was impossible to fracture them in such a manner.